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"Let's Look at the Record"*

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It reaches the Iron and Steel Industry through the Iron and Steel Engineer. In the last five years the Iron and Steel Engineer printed 623 pages, 195 charts, 134 tables covering all types of Rolling Mills. This information was definite, technical engineering facts, not generalities or abstracts.

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Look at the Record

*With apologies to Alfred E. Smith.

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Recent Developments in the Rolling of Sheets and Strip

By STEPHEN BADLAM

STEPHEN BADLAM

EDITOR'S NOTE—Mr. Stephen Badlam, Consulting Engineer, Pittsburgh, Pa., presented to the Iron and Steel Industry, at our Convention October 18, 1933, a review of the Recent Developments in the Rolling of Sheets and Strip. Mr. Badlam, a recognized engineering authority in the Steel Industry, has a thirty year background in Steel activities. He was educated in the Boston Public Schools, attended Massachusetts Institute of Technology and graduated in 1900. His steel mill record is as follows: Laboratory Work at the Duquesne Steel Works during vacation while attending M. I. T. From 1900 to 1912 employed by the Pennsylvania Steel Company. From 1912 to 1914 by the Pittsburgh Crucible Steel Company, 1914 to 1917 by the Pittsburgh Seamless Tube Company. In 1917 he was Captain and Major G-1 First Army, A. E. F. After his service in the Army he was with the Philadelphia Roll Machine Company. In 1922 he entered the employ of the Superior Steel Company as Works Manager. Since 1927 he has been a Consulting Engineer with offices in Pittsburgh, Pa. Mr. Badlam's paper renders a valuable engineering service to the Iron and Steel Industry which will be used as a guide for future expansion in Sheet and Strip production.

Introductory

The intent of the present paper is to outline some of the outstanding developments in the rolling of thin, flat material, over 24″ in width, variously known as "Sheets" and as "Broad Strip".

The period under consideration is that covered by the years from 1926 to date, and it is marked by changes in the rolling mill art, probably greater than in any like period of its history.

The outstanding feature of these developments may be taken to be the production of wide, thin, flat material, within the required tolerances, in long lengths, whereby the processing is made possible, with a minimum of labor, and a maximum yield, both in the production of the material itself, and the products made from it.

The production of such material was the key that unlocked the door to the developments which form the subject of this paper.

Special consideration will be given to the cold rolling of broad strip, but inasmuch as the production of a hot rolled strip of the required width is a prerequisite to the cold rolling, our first consideration will be a more or less general review of the hot rolling art, as applied to strip.

Definition of Product

It may be well, at the outset, to define Sheets and Strip, it being understood that these definitions are for the purposes of this paper, only, and may differ somewhat from the accepted definitions.

Sheets may be defined as: Flat rolled steel, (or other metal), having a high ratio of width to thickness, and rolled in short lengths. Sheets are generally over 24″ in width, under 3/16″ in thickness, rolled in lengths of under 16 feet, and are always handled in the flat.

Strip may be defined as: Flat rolled steel, (or other metal), having a high ratio of width to thickness, and rolled in long lengths. Strip may be of any width, generally under 3/16″ in thickness, rolled in lengths of over 100 feet, and is generally handled in coils.

Wide Strip is that portion of the above, ranging from 12″ to 24″ in width.

Broad Strip is that portion ranging from 24″ upward, to the upper limit of the product of the existing Broad Strip Mills, now about 72″.

The new N.R.A. steel code makes no distinction, in their classification, of what is defined above as Broad Strip, all flat rolled steel, over 24″ in width, and under ¼″ in thickness, being classified as Sheets, and below 24″ in width as Strip.

These definitions are based upon dimensional properties only, but they also presuppose different methods of production. There are, consequently, different physical characteristics for strip and for sheets. This difference is caused primarily by the different working tem-

peratures. Hot rolled sheets, on account of the lower temperatures, to which they are subjected during rolling, generally require additional heat treatment before they can be used for further processing. Hot rolled strip, on the other hand, on account of the higher working temperature, has a structure such that, for most purposes, it can be subjected to further processing, in the condition in which it leaves the rolls. Sheets, in the thinner gages, are always hot rolled in packs of two or more, while strip is hot rolled in a single thickness, (other than the experimental ply rolling at the Acme Steel Co.)

Cold rolled strip and cold rolled, (full finished) sheets are in general, interchangeable in the purposes for which they may be used.

In the narrower sizes of strip, the criterion of a high ratio of width to gage does not strictly apply. With the same upper limit of thickness, 3/16", as the width decreases, the ratio of width to thickness is correspondingly lowered. For example, while a size such as 1" by 1/8" would still be classified as strip, it would have a ratio of width to thickness of only 8 to 1.

Historical

Inasmuch as the historical background of the art has already been published, a brief resumé, only, will be given here.

For many years sheets had been obtainable in any desired gage, and in such widths as were demanded by the trade but were limited in length to about 12 to 16 feet. Strip had been obtainable in any length desired, up to several hundred feet, but was limited in width and gage.

The methods of sheet production had remained substantially unchanged in principle since the introduction of the art, in the middle of the eighteenth century.

Prior to the existing mills there had been attempts to produce wide thin material by a continuous process, but none of them were permanently successful. Of these early attempts, there were three which met with some measure of success and some mention of which can hardly be omitted. These were the Teplitz mill, and the two Bray mills.

Many other mills for the continuous, or tandem, rolling of sheets were proposed during the years from 1892 to 1923 but, as far as known, were never advanced beyond the paper stage, and made no impression on the art. It is probable that the patents granted for mills of this type, with their accessories, would be numbered in the hundreds.

In 1923, however, a mill was built for the continuous rolling of sheets, that was successful, and that had an important effect on the art of flat steel rolling. This was the Ashland Mill of the American Rolling Mill Co.

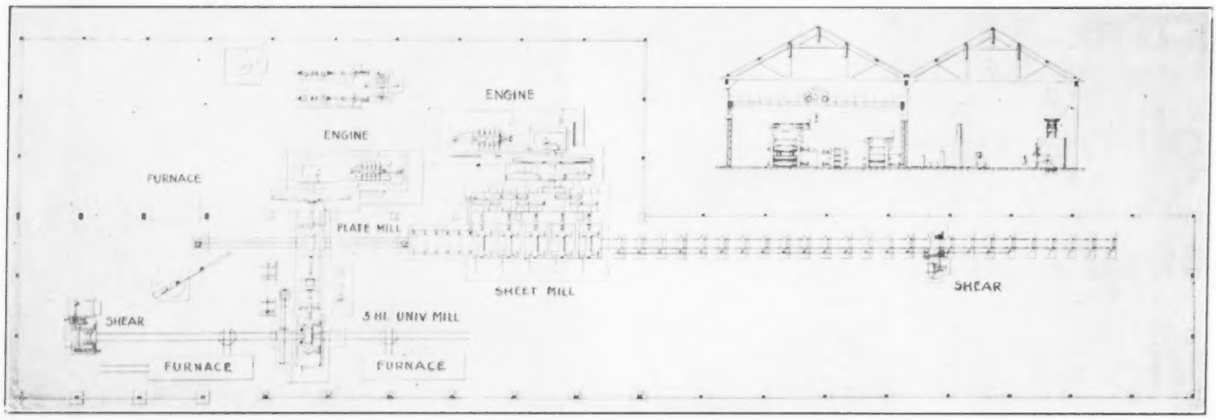

FIG. 1—Continuous Sheet Mill Rudolphshutte Teplitz, Bohemia, 1892.

The art of strip rolling, on the contrary, had been passing though a definite course of development, beginning in the 1870's with the old type of hand mill, through the looping mill and the combination looping mill with continuous rougher, and culminating in 1923 in the straight continuous mill. Each of these formed a distinct contribution to the art of flat steel rolling.

Prior to 1890 the maximum width that it was possible to obtain, in both hot and cold rolled strip, was about 5". By 1893 this had been stepped up to about 7", and in 1901 to about 12" and in 1905 to 16". The maximum width obtainable was increased a few inches at a time until about 1920, when the figure reached 24", at which figure it remained until the advent of the Columbia Steel Co. mill, at Butler, Pa., where, in 1926, it was increased in a single step, to 36". During this course of development the width obtainable in any given gage showed a progressive increase, but the minimum gage in the maximum width remained approximately constant, at about No. 12 gage, or somewhat heavier.

The year 1926 marks the first commercial production of flat rolled steel, over 24" in width, No. 12 gage, or under, in long lengths, and may be said to mark the dividing line between the old and the new, in flat steel rolling. This ratio of width to thickness was above that obtainable, in long lengths in any prior hot rolling practice, and may be taken as of the order of 360 to 1. This and higher ratios were, of course, obtainable in the conventional plate and sheet mills, but in short lengths only. These long lengths of thin wide material were able to meet gage tolerances, at least equal to, and commonly better than, those obtainable in short lengths.

Since 1926 the increase in the width obtainable, in the hot rolled strip, has been rapid, to 48" in the succeeding year, to 52" in 1928, to 54" in 1929, to 66"

and then to 72" in 1932. In 1931, flat lengths, but not coils, became obtainable, up to 90" in width.

The maximum ratio of width to gage, obtainable in the hot rolled has shown a corresponding increase, and at the present time, may be taken as of the order of 750 to 1, and in one case at least, reaching 900 to 1.

Teplitz Mill

One of the earliest attempts to roll sheets by other than the conventional methods was made in Germany, in 1892. In this year a German engineer, Karl Wittgenstein by name, built for the Rudolphshütte, in Teplitz, Bohemia, a mill for the rolling of sheet like material that only missed success by a narrow margin.

The Teplitz mill comprised a three high universal plate mill, in which a slab ingot was reduced to a slab about 2" in thickness, which after cutting in two and reheating was further reduced on a three high plate mill, of the Lauth type, to a plate about ¼" in thickness, and then, without further reheating, was passed through a continuous train of five stands of rolls of the two high, sheet mill type.

The universal mill and the Lauth mill were side by side, on the same shoes, with the pinions between, and were driven by one 1,000 H. P. steam engine. The five stands of two high rolls were arranged in tandem with the Lauth stand, and were driven by a second 1,000 H. P. steam engine, through gearing. Fig. 1.

This mill was in more or less active operation for about 15 years, and produced sheets up to 50" wide, .078" gage and heavier, and in lengths up to about 60 feet. The product of the mill was, however, of so ununiform a gage, from end to end, that it was necessary to cut the sheet into shorter lengths and sort them into about three commercial gages. It is understood that attempts were made to use the product of this mill as breakdowns for the conventional sheet mills but that this was found impracticable.

The mill finally ceased operations, and was abandoned about 1907.

Bray Mill, Monongahela Works

The most ambitious attempt to roll sheet width material, by other than the conventional methods, was made by C. W. Bray, in 1902, at the Monongahela Works of the American Tin Plate Co., Pittsburgh, Pa. This mill was designed to eliminate the hand roughing, or breaking down, of sheet bars in the manufacture of tin plate, duplicating mechanically the first part of the "three part hot rolling system" for tinplate.

The process started with the conventional tin bar, of about 16 lbs. in weight, and about 8" by ⅜" by 20½" in size. The bars were heated in four continuous heating furnaces each accommodating three rows of bars which were fed through the furnace by mechanical means.

The roll train consisted of eight stands of two-high rolls, 26"x32" of the usual tin mill type, arranged in tandem, and spaced on 8 ft. centers, with the exception of stands 6 and 7, which were spaced on 11 ft. centers, to accommodate a matcher. The stands following the matcher were placed 3 ft. lower than the stands preceding it. The first four stands and the last four stands were each driven by a 650 H.P. steam engine, running at a speed of 28 R.P.M., which was also the speed of the rolls, or about 190 feet per minute. Fig. 2.

The heated bars were taken from the furnaces by a conveyor and delivered to the front of the first stand of rolls where they were taken off sideways, by a chain, and delivered singly to the first stand of rolls, and then passed from set to set of the first six stands.

As the piece left No. 6 stand, now about 30" long, it was discharged onto a sloping table, the following piece discharged on top of it, and the two matched by hand. The matched pair was then released by a hand operated lever and gate, entered into pass No. 7, then into No. 8, and emerged as a pack of two sheets, about 56" long and 20½" wide.

After leaving No. 8 pass, the pack passed to a mechanical doubler, and was folded into a pack of four. The remainder of the rolling was done on the regular hot mills, in the usual manner, the pack of four being reheated, rolled, doubled again, heated and rolled into a pack of eight, which was trimmed into two packs, 20" by 28" by No. 28 gage.

The Monongahela mill was operated more or less regularly from January, 1904, to July, 1905, producing material for the ordinary grades of tin plate. The labor saving from this method of rolling was esti-

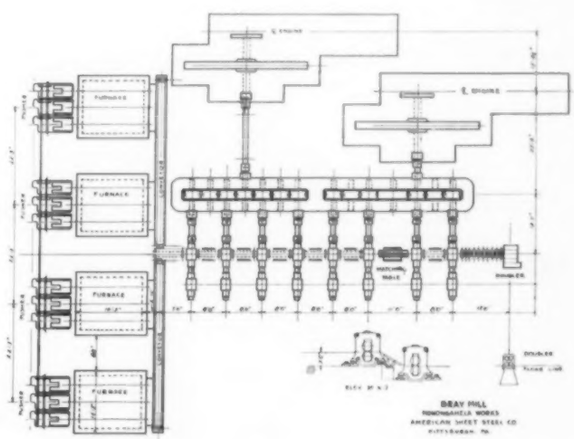

FIG. 2—Bray Mill, Monongahela Works, American Sheet Steel Co., Pittsburgh, Pa.

mated at approximately $2.00 per ton, but this was largely dissipated by higher scrap loss, roll breakage, and increased percentage of seconds. In the absence of definite savings it was considered advisable, in 1905, to shut the mill down and proceed with the development of a sheet rolling mill, as it was felt that with the heavier gage of sheets, as compared with tin plate, it would stand a better prospect of success.

Bray Mill, Mercer Works

The experience gained at the Monongahela mill was deemed sufficiently encouraging to warrant the construction, on a more ambitious scale, of a second mill, at the Mercer Works, Farrell, Pa. The design of the Mercer mill was based on the same principles as that of the Monongahela mill, with such modifica-

tions as the previous experience had indicated as desirable, and as the heavier material to be rolled, called for.

Sheet bars were used, these being somewhat heavier than the tin bar used in the earlier mill, and it was deemed advisable to install nine stands of rolls, 28" x 39" instead of eight, and the stands, after the first three, were placed on somewhat longer centers. A mechanical matcher was placed after the sixth stand, and a pack of three, instead of two, rolled in the last three stands. The entire mill was driven from a single 1800 H.P., 75 R.P.M. engine, through a combination of rope and gear drives, the roll speed being approximately 30 R.P.M., or 220 feet per minute. Stands 1, 2 and 3 were driven through pinions, while the remaining stands were friction driven.

The pack of three, on leaving the mill passed through a roller leveler, to loosen, and then to a mechanical doubler. The doubled packs were delivered to the furnaces of a hot sheet mill of the conventional type, and finished in the usual manner, with a single heating, to an average gage of 25½.

The Mercer mill operated intermittently from November, 1905, to May, 1910, when, on the breakage of the main drive shaft, it was felt that any further expenditures on the mill would not be warranted, and it was shut down and dismantled.

Ashland Mill

The earliest of the now existing mills, was that of the American Rolling Mill Co., at Ashland, Ky., built in 1923.

Reversing two high Blooming Mill.
Tandem Bar Plate Mill.
Tandem Rough Sheet Mill.

In these three units the ingot is rolled down to a slab, a bar plate, and a rough sheet, respectively, without being allowed to become cold.

The Ashland Mill is of the Continuous Sheet Mill type and is the only one of the kind. The sheet mill proper, consists of two trains, a Bar Plate Mill of seven flat stands and two edgers, later increased to four, and a Rough Sheet Mill of seven stands of flat rolls. Each train is arranged in tandem, and the two trains are separated by a distance of 228'5". In the Bar Plate Mill stands 1-2-3 are two high, with balanced top roll, and driven through pinions, while stands 4-5-6-7 are two high with the bottom roll positively driven, and the top roll driven through a light spindle and slip coupling, from the gear reduction. The vertical edging rolls are driven from the horizontal roll, gear reduction. In the Rough Sheet Mill stands 1-2-3 are two high, and stands 4-5-6-7 are three high, with small middle roll. In all stands the bottom roll, only, is driven.

The rolls are equipped with plain bearings throughout, with the exception of one of the three high stands, which is now experimentally equipped with two bearings of the Morgoil type, on the upper roll.

Preceding the first stand of the Bar Plate Mill is a continuous slab holding furnace, and preceding the first stand of the Rough Sheet Mill is a similar furnace for the bar plate. Between the holding furnaces

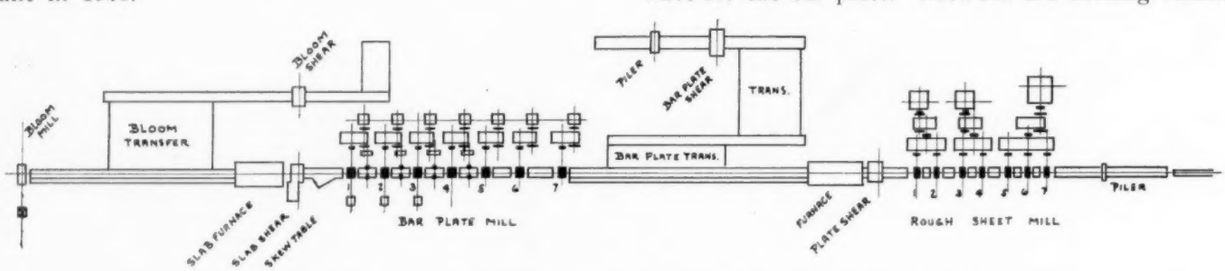

FIG. 3—Continuous Sheet Mill American Rolling Mill Company, Ashland, Ky.

During the years from 1913 to 1921, the American Rolling Mill Co., with plants at Middletown and Zanesville, Ohio, had been conducting a series of experiments with the object of determining the fundamentals of sheet rolling, and had developed a plan for a continuous, or tandem, rolling of sheets. Like previous attempts, the plan was based upon sheet, rather than upon strip, practice.

The purchase by the American Rolling Mill Co., in December, 1921, of the properties of the Ashland Iron & Mining Co., at Ashland, Ky., offered the opportunity of trying out these plans on a major scale. It was proposed to build a sheet mill which would take a 10,000 lb. ingot, and without allowing it to become cold, to reduce it to 16 gage, and heavier, sheets, of the usual widths and lengths, and after reheating, to further reduce to 22 gage, and heavier.

Construction was commenced early in 1923, the first bar plate was rolled in December of that year, and the first sheet in January, 1924.

The installation in brief, consisted of the following major units:

and the first stand of each train is a dividing shear for cutting the slab and the bar plate, into suitable short lengths.

The Ashland Mill rolls in short lengths, only, not over 30 feet, and finishes at speeds of approximately 600 feet per minute. The temperature of the piece, during rolling, is low, being comparable with that customary in sheet practice, rather than strip practice. Fig. 3.

Supplementing the Bar Plate Mill, and the Rough Sheet Mill, there is a finished sheet mill, for the production of the lighter, finished sheet gages.

On leaving the Rough Sheet Mill, the sheets are allowed to become cold, and when lighter sheets are desired, are pickled, and further reduced in the sheet mill, which comprises five stands of three high rolls, and four continuous, reheating furnaces, one long furnace before the first stand, and three, shorter, furnaces preceding stands No. 3-4-5.

In 1927, a tandem cold mill, of five stands of four high rolls, was added, as an alternative method of reduction. This cold mill will be described, in more detail, later.

American Rolling Mill Co., Ashland

CHARACTERISTICS OF MILL AND DRIVE
BAR PLATE MILL

No. of Pass	St.	ROLLS Kind	Diameter	Length	F.P.M.	Dist. to Next St.	MOTORS H.P.	R.P.M.	Volt	Cur.
1	1	Hor 2Hi	30″	58″	110	10′0″	300	585	6600	60cy
2	1–E	Ver edg				9′0″				
3	2	Hor 2Hi	30″	58″	157	10′0″	300	585	6600	60cy
4	2–E	Ver edg				10′0″				
5	3	Hor 2Hi	30″	58″	196	10′0″	300	585	6600	60cy
6	3–E	Ver edg				9′0″				
7	4	Hor 2Hi	30″	58″	196	10′0″	500	585	6600	60cy
8	4–E	Ver edg				10′0″				
9	5	Hor 2Hi	30″	58″	196	19′0″	500	585	6600	60cy
10	6	Hor 2Hi	30″	58″	283	24′0″	600	870	6600	60cy
11	7	Hor 2Hi	30″	58″	283		600	870	6600	60cy

ROUGH SHEET MILL

No. of Pass	St.	ROLLS Kind	Diameter	Length	F.P.M.	Dist. to Next St.	H.P.	MOTORS R.P.M.	Volt	Cur.
1	1	Hor 2Hi	30″	58″	353	11′0″				
2	2	Hor 2Hi	30″	58″	353	15′0″	2000	505	6600	60cy
3	3	Hor 2Hi	30″	58″	353	11′0″				
4	4	Hor 3Hi	14″–30″	58″	353	15′0″	2000	505	6600	60cy
5	5	Hor 3Hi	14″–30″	58″	339–507	11′7″				
6	6	Hor 3Hi	14″–30″	58″	400–522	10′11½″	4000*	247–370	6600	60cy
7	7	Hor 3Hi	14″–30″	58″	448–667					

*Replacing 1800 H.P. Motor.

FINISHED SHEET MILL

No. of Pass	St.	ROLLS Kind	Diameter	Length	F.P.M.	Dist. to Next St.	H.P.	MOTORS R.P.M.	Volt	Cur.
1	1	Hor 3Hi	14″–30″	48″	196		300	585	6600	60cy
2	2	Hor 3Hi Reheated	14″–30″	48″	196	56′10¾″	300	585	6600	60cy
3	3	Hor 3Hi Reheated	14″–30″	48″	196	59′10¾″	300	585	6600	60cy
4	4	Hor 3Hi Reheated	14″–30″	48″	196	59′10¾″	500	585	6600	60cy
5	5	Hor 3Hi	14″–30″	48″	196		500	585	6600	60cy

The stage was now set for the appearance of the broad strip mill, and it may be desirable, at this time, to review the status of the art of flat steel rolling, as of the middle of the year 1926.

Sheets were being produced, on the conventional sheet mills, in widths up to about 54″, in all gages desired, and in lengths up to from 8 to 16 feet, varying with the gage. The Ashland Sheet mill was in operation, producing sheets in the same widths and lengths, and in gages of No. 16 and heavier by a continuous process, from the initial heat of the ingot, and in gages from 24 to 18, by reheating, and further hot rolling.

Hot rolled strip was being produced in gages No. 12 and heavier, up to 24″ in width, and as thin as 20 gage in the narrower widths. Cold rolled strip was being produced in widths limited by available hot strip, and in the then practical gages.

The demand for flat rolled steel, especially by the auto-motive industry, was rapidly increasing in volume, particularly in the range from 24″ to 48″ in width, and in gages from No. 16 to 24, and was beginning, for the lighter gages, in widths from 54″ to 72″.

It was at this stage of affairs that in November 1926, the mill of the Columbia Steel Company, at Butler, Pa., went into operation in an effort to meet the demand for both strips and sheets, in widths up to 36″, and in gages required by the auto-motive industry, thus increasing the width of material rolled in strip form to sheet widths.

Columbia Steel Co., Butler, Pa.

The Broad Strip Mill of the Columbia Steel Co., at Butler, Pa., was built in 1926 and went into operation in November of that year. Since 1927 it has been owned by the American Rolling Mill Co.

The Butler mill used as raw material, slabs from 2½" to 4" in thickness, and in widths from 12" to 36", in lengths up to 12'6". These were reheated in two 14' by 55' continuous heating furnaces.

The mill proper comprises a single stand, two high reversing rougher, in which the piece receives from three to seven passes, followed by four stands of four high rolls, arranged in tandem, and spaced closely together. The finishing train was built by the United Engineering & Foundry Co., and was equipped with roller bearings on the backing rolls, this being the first hot mill installation having backing rolls so equipped. The piece is engaged in all four stands at the same time, is rolled at a high speed, 460 to 920 feet per minute, with heavy drafts, and in a long length, approximately 300 feet. Fig. 4.

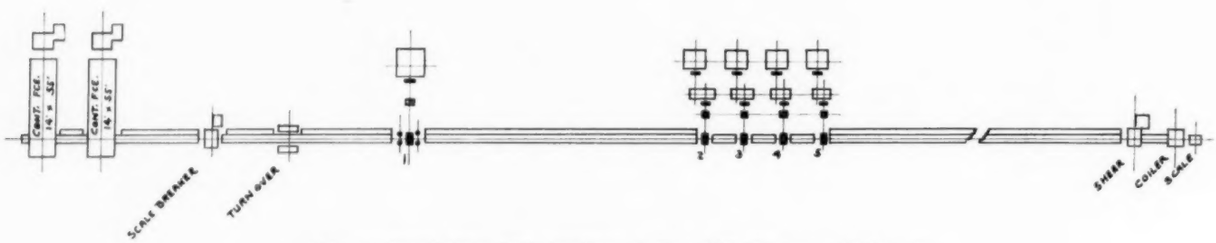

FIG. 4—Broad Strip Mill American Rolling Mill Company, Butler, Pa.

CHARACTERISTICS OF MILL AND DRIVE

No. of Pass	St.	Type	ROLLS Diameter	Length	F.P.M.	Dist. to Next St.	MOTORS H.P.	R.P.M.	Volt	Cur.
1										
2	1-E									
3	1	Univ 2Hi	27"	48"	0–1060	165'0"	5000	0–150	700	DC
4	1-E									
5										
6	2	Hor 4Hi	16½"–32"	42"	233–466	22'0"	2000	200–400	600	DC
7	3	Hor 4Hi	16½"–32"	42"	321–642	22'0"	2000	200–400	600	DC
8	4	Hor 4Hi	16½"–32"	42"	404–808	22'0"	2000	200–400	600	DC
9	5	Hor 4Hi	16½"–32"	42"	460–920		2000	200–400	600	DC

Number of passes in Universal stand vary from 3 to 7.
Shear.
Hot coiler.

Columbia Steel Co.
(American Rolling Mill Co., Butler Plant)

In 1929 some changes were made in the finishing train and the first three stands were replaced by heavier units, all four stands were widened to 48", and the speeds substantially increased.

CHARACTERISTICS OF MILL AND DRIVE
REVISED

No. of Pass	St.	Type	ROLLS Diameter	Length	F.P.M.	Dist. to Next St.	MOTORS H.P.	R.P.M.	Volt	Cur.
1										
2	1-E									
3	1	Univ 2Hi	27"	48"	0–1060	165'0"	5000	0–150	700	DC
4	1-E									
5										
6	2	Hor 4Hi	16½"–38"	48"	372–744	22'0"	2000	200–400	600	DC
7	3	Hor 4Hi	16½"–38"	48"	461–922	22'0"	2000	200–400	600	DC
8	4	Hor 4Hi	16½"–38"	48"	528–1057	22'0"	2000	200–400	600	DC
9	5	Hor 4Hi	16½"–32"	48"	659–1318		2000	200–400	600	DC

Number of passes in Universal stand vary from 3 to 5.
Shear.
Hot coiler.

Definitions of Process

It may be well at this time to draw a distinction between the continuous sheet mill and the broad strip mill.

The Continuous Sheet Mill may be defined as a mill, for the production of wide, thin, flat material, having a plurality of roll stands, the piece progressing in the same direction from stand to stand, but not generally in more than a single stand at the same time.

The finished piece is comparatively short, and the rolling temperatures, and the finishing speeds, are lower than in strip practice.

The Broad Strip Mill is a mill for the production of wide, thin, flat material, having a plurality of roll stands, the piece progressing in the same direction, from stand to stand, and in which, in the later passes, the piece is engaged in two or more stands, at the same time.

The finished piece is comparatively long, and the rolling temperatures, and the finishing speeds are higher than in sheet practice.

There are now in operation, in this country, twelve hot mills of these two types. The first, the Ashland Mill is of the continuous sheet type, and is the only one of the class. The other eleven are all of the broad strip type. Of these the first to be built, the Butler Mill, fails to fully meet the definition above, as the first stand is a reversing universal mill, in which the piece receives several passes, reversing its direction between.

Three of the mills, while of the same type, and meeting the definition given, were designed for somewhat different purposes, and were not initially provided with means for coiling the product as it left the mill.

The Gary mill was designed for the production of breakdowns for finishing in the conventional tin mills, and means were provided for handling the product, in flat lengths of about 180 feet, for transfer into an adjoining bar storage.

The Allegheny Steel Co. mill was designed primarily for the production of breakdowns for the conventional sheet mills, modified for semi-automatic operation, and was equipped with rotary flying shear and bar piler, for handling the product in about 30-foot lengths, for loading into cars.

Both of these mills have since added equipment for hot coiling the product, when desired.

The Illinois Steel Co. mill was designed for the production of the heavier gages, of the order of plates, rather than of strip, and was provided with cooling beds, conveyors, and cold shears, for handling the product. It is, as yet, without means for handling the product in coils.

List of Hot Mills

In addition to the two pioneer mills, the Ashland Mill of the American Rolling Mill Co., and the Butler Mill of the Columbia Steel Co., there are now in operation in this country the following mills for the production of wide, thin, flat material, in long lengths. All these mills are characterized by having a separate stand for each pass, arranged in tandem, and at least some of the stands are of the four high, backing roll type, equipped with roller bearings on the backing rolls.

Company	Size	Location
Trumbull Steel Co.	36"	Warren, O
Weirton Steel Co.	54"	Weirton, W. Va.
Am. Sheet & Tin Plate Co.	36"	Gary, Ind.
Am. Rolling Mill Co.	58"	Middletown, O.
Wheeling Steel Corp'n	60"	Steubenville, O.
Great Lakes Steel Corp'n	38"	Ecorse, Mich.
Illinois Steel Co.	96"	So. Chicago, Ill.
Otis Steel Co.	72"	Cleveland, O.
Inland Steel Co.	76"	Indiana Harbor, Ind.
Allegheny Steel Co.	38"	Brackenridge, Pa.

Engineering Factors

Among the factors which have made these developments possible from an engineering standpoint, there are two of special interest to the members of this Association, and in which they have played no small part. These two factors are:

First: The adjustable speed, D.C. electric motor, with its control.

Second: The backing roll mill with anti-friction bearings.

The adjustable speed, D.C. electric motor has made possible the rolling of wide, thin material in a continuous mill, and the four high, backing roll mill, with anti-friction bearings on the backing rolls, has made such rolling possible, within the required tolerances, in long lengths, and at high speeds.

Prior to the use of the individual, D.C. adjustable speed, motors, in the continuous mill, it was customary practice to drive the several stands from a single engine, or motor, by belts, or through gearing. The speed ratios were arranged to correspond to an average, or normal, series of drafts, and a given roll diameter.

While this was quite satisfactory for shapes such as rounds and squares, narrow flats, and the like, it was unsuitable for wide, thin, flat sections, and the rolling of this class of material would have been difficult, or impossible. The use of individual, adjustable speed, D.C. motors, on each stand, permitted an adjustment of the speeds to suit any draft required, and rendered the continuous rolling of wide strip possible.

Prior to the general utilization of the backing roll mill, with anti-friction bearings, although some anticipations are to be found, the usual form of mill for the rolling of wide flat sections, was the two high mill with plain bearings. With such bearings it was considered impossible to roll such material, either in long lengths, or at high speeds. At the time it was assumed that the space limitations were such as to prevent the use of adequate anti-friction bearings on the necks, and that it was only by the use of backing rolls, that such bearings could become practicable. Within the past few years, however, with the introduction of flood oiled bearings, of the Morgoil type, these limitations have to some extent, been removed.

In order to avoid an undue extension of the part of this paper, relating to the hot rolling of strip, instead of treating separately each of the ten mills built since 1926, we will describe the characteristic features of them, as a whole.

General Characteristics

The general characteristics of the hot mills of the broad strip type, built since the Butler mill are:

First: A series of three to five stands of flat rolls, arranged in tandem, the piece running free of each stand, before entering the succeeding stand. Interposed between the flat stands are two or more edging stands.

Second: A series of four to eight stands, of flat rolls, spaced closely together, the piece entering each stand, after the first, before leaving the preceding stand.

The total number of flat pass stands varies from nine to eleven, usually ten, except in one case in which there are seven only.

In all cases the strip mills start with a slab of about 3", or more, in thickness, and of the width of the finished strip, (unless the capacity of the blooming or slabbing mill is less than the finished width, in which case the maximum width slab is used and spread in the strip mill.) The slabs used may vary in weight from 1000 lbs. to 10,000 lbs.

The earlier broad strip mills were arranged as independent units, and used slabs which had been allowed to cool, either completely, or partially. The slabs were generally chipped before rolling in the strip mill.

The newer mills are arranged in conjunction with a slabbing or blooming mill, and in the case of the heavier gages, the slabs are rolled at the initial heat, without going through a reheating furnace at the strip mill, and without chipping.

In the case of the Allegheny Steel Co. mill, no furnaces are provided at the present time, although room is left to add them later, if desired.

Roughing Train

The stands of the first, or roughing, train are generally two high, with plain bearings, although in some cases some, or all, of them may be of the four high type with anti-friction bearings, and in one case, a three high stand, of the Lauth type, but used as a single pass stand, is included.

The size of the rolls in the roughing stands show considerable variation, ranging from 22½" x 36", in one case, to 52" x 96" in another. With minor exceptions it has taken the form of a progressive increase, in length and in diameter, as each new mill was constructed.

In the wider mills, where the width of the finished strip is greater than the maximum width of slab available, the first flat pass, after the scale breaker, is arranged as a spreading pass, the slab being entered broadside, and given a reduction sufficient to spread it to the width desired. The piece is then turned to its original direction for the succeeding passes. The spreading stand may be made with a roll face greater than the succeeding stands, in order to accommodate a slab longer than would otherwise be the case.

In the case of the Middletown mill, for the wider sizes, the slab is cut to a length equal to the width desired, and passed through all the stands of the mill, at right angles to its original direction of rolling in the blooming mill. The length of strip is thus limited by the maximum width of slab that can be produced, in this case 36", and in order to obtain a weight sufficient, the slab is made of a thickness of about 6" instead of 3" or 4", as would be the case in the narrower widths, where the length is not so limited.

In this connection it may be suggested that the three high stand, of the Lauth type, would have certain advantages, as a spreading stand, such as the ability to make more than a single pass, and the possibility of cornering the slab, to bring it to a better shape, that may render its use advisable in some of the wider mills, now under consideration.

Intermediate of the roughing stands are edgers, varying in number from two to four. These may either be in the same housings as the flat rolls, universal type, or of the separate, vertical edger type. The edgers are generally driven by separate, adjustable speed motors, although in the case of the Middletown mill, they are driven from the main roll drive. They may be either on the entry side, or on the delivery side, of the flat stands, and sufficiently close so that the piece is in both the vertical and the horizontal rolls, at the same time, or they may be independent of the flat stands.

In two of the mills the first pass is of the horizontal edger type, the piece entering on edge. In two other mills the first pass is a horizontal scale breaker, the amount of reduction being secondary.

Two of the mills are equipped with a hydraulic squeezer, located, in the one case before the first stand, and in the other case, after the spreading stand, which serves to give the slab a definite, and uniform width.

The speeds of the roughing stands of the different mills vary greatly, the speed of the first stand ranging from a minimum of 36 F.P.M. to a maximum of 157 F.P.M., with an average of about 100 F.P.M. The speeds of the last stand of the roughing range from a minimum of 140 F.P.M. to a maximum of 556 F.P.M., with an average of about 250 F.P.M. In most cases the speed of the last stand of the roughing is about 50% higher than that of the first stand of the finishing, in order to reduce, as much as possible, the total time through the mill.

Roughing Drive

The stands of the roughing mill are driven, either by a separate motor to each stand, or by one motor to two stands, three stands, or four stands.

The motors are customarilly A.C. constant speed, of the induction type, no speed regulation being required, and may, or may not, be equipped with flywheels. In one case the motor is of the A.C. adjustable speed, Scherbius type. In another case a synchronous motor is used in one stand. In two cases the roughing mill motors are of the D.C. adjustable speed type. In the cases where D.C. adjustable speed motors are used, they are equipped with separate motor-generator sets, with Ward-Leonard control, giving by generator voltage control, an additional speed range, practically from zero up to the minimum obtainable by shunt field control.

The power applied to the stands of the roughing train shows a wide diversity in practice. It ranges from as little as 800 H.P. for a stand 72" wide, to as much as 3000 H.P. for a stand 38" wide, and from 1500 H.P. for four stands 42" wide to 4000 H.P. for two stands 60" wide. The determining factors in calculating the H.P. required, are the width and draft, the speed, and the length of the piece, and the composition of the metal to be rolled.

Finishing Train

The finishing train consists of from four to eight stands of four high rolls, equipped with roller bearings, usually spaced as closely together as the size of the motors, and gear reductions will permit, from 13 to 24 feet.

The finishing stands, in some cases, are divided into two groups. In the case of the Gary mill there is a first group of two and a second of four stands, and in the Warren mill, two groups of three stands each. In this case the first group of three is driven by a single motor, consequently the drafts in the second and third stands are determined by the fixed speed ratio, and the diameter of the rolls in the mill.

The Middletown mill has two groups, the first of three, and the second of four stands, but these, in effect, consist of two separate finishing trains. They are separated by a space of about 180 feet, and the wider and heavier material may be taken off after leaving the three stand train, without passing through the four stand train.

There are no edging stands in the finishing train as the piece would ordinarily be too thin for effective edge work.

In two cases the roughing and finishing trains are placed closely together. Both these mills have D.C. adjustable speed motors with separate motor-generator sets, on the roughing stands, and are equipped with a special form of control, whereby it is possible to operate them at top speed until the front end of the piece is about ready to enter the first stand of the finishing train, when they are automatically slowed down to the entry speed desired. When the back end of the piece leaves the last roughing stand, the motors are automatically speeded up for the next piece. Thus it is possible to operate with a piece in the last stand of the rougher, and the first stand of the finisher, at the same time.

The delivery speed of the mills ranges from about 500 to 1000 feet per minute, up to about 700 to 1400 feet per minute, the later mills as a rule, showing the higher speeds. The 96" mill of the Illinois Steel Co., however, is designed for a speed of 350 to 700 feet per minute, to be explained by the fact that this mill was designed primarily for heavier gages, of the order of plates, rather than a strip.

Finishing Drive

The finishing stands are necessarily driven by adjustable speed motors which usually have a speed range of two to one. In all the mills built to date, with one exception, the motors are D.C. receiving the current from motor-generator sets reserved for the purpose. The Warren mill is driven by adjustable speed motors, of the A.C. Scherbius type.

In the case of the Allegheny Steel Co. mill the first stand of the finishing train is driven by a constant speed motor, and the following stands by adjustable speed motors. Inasmuch as the first stand of the finishing train receives the piece after it has left the preceding stand, practically as wide a choice of drafts is available as would be the case if the speeds of all the stands were adjustable.

The motors on all the stands of the finishing train are usually of the same H.P. and speed, and drive through reducing gears, the speed required at the rolls being secured by a variation in the gear ratios, so as to secure a progressive increase from the first to the last. In some cases the H.P. of the earlier stands of the finishing train may be less than that of the later stands, and in one case, the H.P. of the last stand is less than that of the preceding stands. It is difficult to see the justification for the first case, and, while the reduction in H.P. for the finishing stand may be justified by the drafts used, it is questionable whether the saving in original cost, and in the electrical efficiency, would not be overbalanced by the advantage of having all the motors identical.

The horsepower of the motors driving the finishing train range from 2000 for rolls from 38" to 42" wide up to 3500 for rolls from 72" to 96" wide, and will average very close to 50 H.P. per inch of width for the usual finishing speeds.

Scale Removal

Probably the most important problem in connection with the hot rolling of broad strip, outside of the rolling itself, is that of securing a finished surface, with a light and uniform scale, readily and completely removed by pickling.

The means adopted for the removal of scale, during rolling, in some of the earlier mills proved inadequate for the purpose, due largely to the lack of adequate provisions for hydraulic water sprays, but in the later mills the problem has been attacked with a great deal of success, and most of the earlier mills have installed additional hydraulic pressure equipment, and have increased the pressure and volume of water available, and the number of points of application.

In the Ashland mill the scale problem never was a serious one, due probably to conditions that were inherent in the method, that is, to the lower and better controlled temperature, due to rolling in short lengths, and the use of holding furnaces, as well as the practice of afterwards pickling the breakdowns prior to hot rolling in the finished sheet mill.

The original equipment of the Butler mill included a scale breaker of the five roll, straightener type, between the furnaces and the universal rougher, and a slab turnover beyond it, which served to remove the greater part of the furnace scale.

Two of the broad strip mills have been provided with a horizontal edging stand, preceding the first flat stand of the mill, and designed to edge the piece in a vertical position. Two others are equipped with a scale breaker stand, in the same location, for use with the slab in a horizontal position. One mill is equipped with a similar scale breaker stand, in the train, preceding the first stand of the finishing.

Representative of the most complete type of scale removing equipment is the Inland Steel Co. mill, with two two-high scale breaker stands, the first preceding the spreading stand, and forming the first pass of the roughing train, and the second immediately preceding the first pass of the finishing train, and continuous with it. The first scale breaker is driven by a constant speed A.C. motor of 1000 H.P., and the second by a D.C. adjustable speed motor of 500 H.P. There are two 1000 gal. per minute, 1000 lb. pressure, hydraulic pumps each with a 1000 H.P. motor, for the water sprays, making a total of 3500 H.P. devoted to the removal of scale alone.

Present Status of the Broad Strip Mill

The continuous broad strip mill for the hot rolling of wide, thin, flat material, has now reached a fairly standardized position, and sufficient operating data has been accumulated so that its capabilities, as well as its deficiencies, are now well understood. It is generally accepted as the most efficient method of production of plates, sheets, and strip within its range.

Range of Product

The commercial range for the mills built to date may be taken as within the following limits:

20 Ga.	.0375″	to 27″ wide
19 Ga.	.044″	to 33″ wide
18 Ga.	.050″	to 36″ wide
17 Ga.	.056″	to 42″ wide
16 Ga.	.0625″	to 48″ wide
14 Ga.	.078″	to 60″ wide
13 Ga.	.094″	to 72″ wide
11 Ga.	.125″	to 84″ wide
7 Ga.	.1875″	to 90″ wide

Gages somewhat less than those shown, for the widths given, have been produced, but under normal operating conditions, such lighter gages are not considered as a commercial proposition. It may be noted that the ratio of width to gage, for the intermediate gages, is of the order of 750 to 1, and such a ratio may be accepted as indicating the commercial possibilities.

It should be understood that no one mill should be expected to produce both the maximum width and the minimum gages shown.

Production

The production of the hot Broad Strip Mill has proved all that, or more than, was anticipated for it, and in general figures, the rate of production may be taken as follows:

Average Width	and Gage	Tons per Mo.
24″	.050″	20,000
30″	.056″	25,000
36″	.063″	30,000
48″	.078″	40,000
60″	.094″	50,000
72″	.125″	60,000
84″	.1875″	70,000

This schedule assumes, of course, a well filled order book, with sufficient tonnage of a size to reduce the percentage of lost time to a reasonable figure, something which most of the mills have not yet experienced.

In general figures, and disregarding existing limitations due to deficiencies of steel supply, or reheating facilities, the capacity of the twelve mills now in operation, may be taken as approximately 500,000 tons per month. Deducting 20% from this figure to cover contingencies of sustained operations, we have 400,000 tons per month, or 4,800,000 tons per year. This figure is considerably greater than the total production of flat rolled steel, over 24″ wide, for the year 1932 and is approximately one-half of the production for the peak year of 1929.

Disposition of Product

The hot rolled product of the Broad Strip Mill has found a place in the finished steel market as light plates, as skelp for the manufacture of pipe, either by the fire welding process, or by the gas or electric welding processes, as hot rolled strip, and as hot rolled sheets in the heavier gages.

The product of the Broad Strip Mill has also found a fairly large, and increasing field, in the production of breakdowns for the conventional sheet or tin mill, or for the newer semi-automatic modifications of the conventional sheet mill.

The hot rolled product also forms the semi-finished material for the production of finished strip, or sheets, in the lighter gages, on the tandem, or single stand, cold strip mills. For this purpose it is applied in coils of the maximum length produced on the hot mills.

One phase of this that has recently been given a tremendous impetus is the production of strip for tinning, replacing the black plate now produced, either by the conventional method throughout, or from strip mill breakdowns, finished on the conventional tin mills.

The Conventional Sheet Mill

The future status of the conventional two high sheet mill, in view of the development of the Broad Strip mill, is a question that is engrossing the minds of many operators in the flat rolled steel industry. How can the production of sheet material, in short lengths, on the existing equipment, be accomplished under present competitive conditions?

The question seems to be in a fair way towards being answered by the introduction of the continuous pair and pack furnaces, the automatic feeder and catcher, mechanical matchers and doublers, and the three high water mill.

Excellent examples of what have been accomplished along these lines are to be found in the sheet mills all over the United States, and even in far off India. Further discussion of this phase of sheet production will not be entered into here, as it will be treated of, in full, in the paper presented by Mr. R. J. Wean.

Cold Rolling of Broad Strip

While the mills for the hot rolling of broad strip were undergoing the course of development outlined in the foregoing paragraphs, mills for the cold rolling of the product of the hot mills were in a course of development closely paralleling that of the hot rolling. Every advance in the width obtainable on the hot mills was promptly followed by a corresponding advance in cold rolling.

For the cold rolling of strip in widths greater than 24″ the old two high mills would have been totally inadequate, heavy reductions, or high speeds, would have been impracticable. For these wider widths the solution of the problem was the backing roll mill equipped with anti-friction bearings, and its use today is practically universal.

The use of maximum length coils is of even greater importance in cold rolling than it is in hot rolling, and there are in common use today coils of

36" width and a weight of 6000 lbs.; or in .010" gage, a length of 5000 feet.

The ratio of width to thickness obtainable in the cold rolled, has been increased in even greater proportion than is the case in the hot rolled, and today it is possible to obtain cold rolled strip, in wide widths, of a ratio of 3600 to 1.

Historical

Prior to the introduction of the modern backing roll mill, equipped with anti-friction bearings, practically all cold rolling was done on two high mills with plain bearings.

There were, to be sure, some anticipations of the use of backing roll mills, both with plain bearings, and with anti-friction bearings. It is of some interest to note that the first development of mills, other than the ordinary two high type, was for cold rolling purposes.

Three high, "Baby Roll" mills, of the Lauth type were used at quite an early period for the cold rolling of strip. About 1880 Mr. S. R. Wilmot, of the Wilmot & Hobbs Mfg. Co., at Bridgeport, Conn., introduced the four roll type of mill in which the baby roll was supported upon two backing rolls below, instead of one. About 1909 the American Tube & Stamping Co., which had succeeded the Wilmot & Hobbs Mfg. Co., brought out the so-called "Keating Mill," which was of the cluster, or six roll type, and was equipped with roller bearings on the backing rolls.

Huntington Mill, International Nickel Co.

One of the most influential factors in starting the trend of thought which culminated in the design of the broad strip mill, as we now know it, was the cluster mill built by the E. W. Bliss Co., for the Huntington plant of the International Nickel Co., at Huntington, W. Va.

This mill was designed and built, in 1923, along the lines of the Keating Cluster mill, for cold rolling nickel and Monel metal sheets up to 36" in width. It was equipped with plain bearings on the backing rolls, as at the time, no maker of anti-friction bearings was able, or willing, to furnish a guarantee that such bearings would stand up under the pressures involved in this application.

The mill proved so successful in cold rolling the Nickel and Monel metal sheets that it, at once, attracted the attention of sheet and strip makers all over the country, in the steel as well as in the non-ferrous industry.

In 1926 a duplicate of this mill was built for the Huntington plant. In 1930 one of these mills was equipped with tapered roller bearings on the backing rolls, and in the following year the second mill was so equipped. Fig. 5.

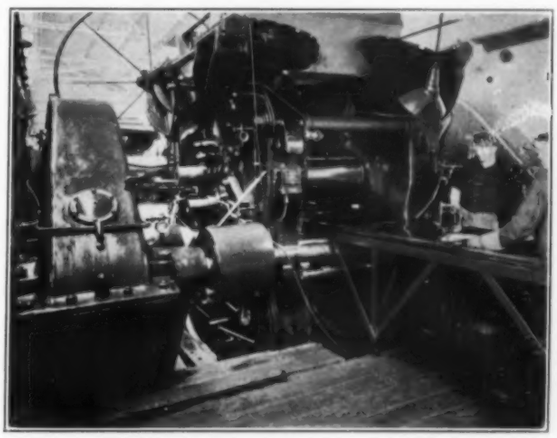

FIG. 5—Cluster Mill, International Nickel Company, Huntington, W. Va.

CHARACTERISTICS OF MILL AND DRIVE

	ROLLS				MOTORS		
Mill	Diameter	Length	F.P.M.	H.P.	R.P.M.	Volt	Cur.
Single Clus.	12"–24"	42"	80–160	750	300–600	230	DC
Single Clus.	12"–24"	42"	80–160	750	300–600	230	DC

Rome Brass & Copper Co., Rome, N. Y.

In 1925, or shortly after the Huntington cluster mill went into operation, the United Eng. & Fdy. Co. built a four high, backing roll, mill for the Rome Brass & Copper Co., Rome, N. Y., for cold rolling brass and copper sheets up to 42" in width. This

CHARACTERISTICS OF MILLS AND DRIVES

		ROLLS				MOTORS		
Mill	St.	Diameter	Length	F.P.M.	H.P.	R.P.M.	Volt	Cur.
Tandem	1	14"–32"	48"	88–176	400	400–800	230	DC
	2	14"–32"	48"	112–224	400	400–800	230	DC
	3	14"–32"	48"	149–298	500	400–800	230	DC
	4	14"–32"	48"	183–366	500	400–800	230	DC
Single	Reel	14"–32"	48"	112–224	100			
Single*	Reel	14"–30"	48"	112–224	100			

*Original mill.

mill was equipped with roller bearings on the backing rolls, these bearings being made by the Hydraulic Tool Co., now the Messinger Bearings, Inc., of Philadelphia, Pa. We must give this company the credit for being the first to be willing to build, and put their guarantee back of, a roller bearing application, involving the rolling of thin, wide material. Fig. 6.

The Rome mill was the first of the large, modern type, mills equipped with anti-friction bearings, and it became the model upon which the succeeding four high mills, both hot and cold, were built.

In 1927 four additional mills, of the same design, but heavier, and with larger backing rolls, were built for the same company, and in 1929 an additional mill was built.

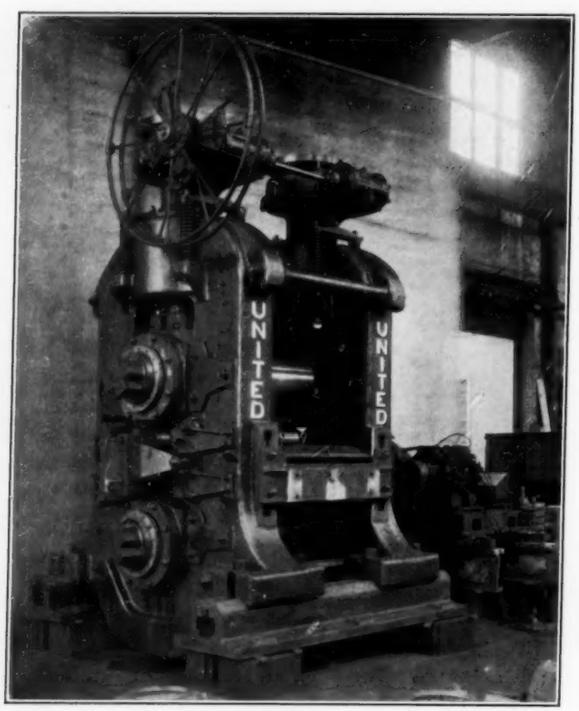

FIG. 6—Four High Cold Mill, Rome Brass and Copper Co., Rome, N. Y.

Columbia Steel Co.

(Butler Plant, American Rolling Mill Co.)

When the first hot mill of the Broad Strip type, that of the Columbia Steel Co., at Butler, Pa., was

FIG. 7—Four High Cold Mill, Columbia Steel Company, Butler, Pa.

contemplated, there was designed, in connection with it, a mill for the production by cold rolling, of sizes having a ratio of width to thickness greater than that which it was expected to produce by hot rolling. At the time this ratio was expected to be about 480 to 1, or a minimum of about 16 gage in 36" width, with somewhat lighter gages in the narrower widths.

The cold rolling installation was built, and placed in operation in December, 1926. It comprised six stands of four high rolls, built by the E. W. Bliss Co., the backing rolls of which were equipped with roller bearings of the tapered roller type, made by the Timken Roller Bearing Co.

Four of the stands were arranged as a tandem train, with a roll coiler following the last stand, and the other two stands as singles, with a tension reel for each. Fig. 7.

In addition to the hot rolling and cold rolling equipment there was installed at this time:

One continuous pickler,

One continuous annealing furnace,

Flattening and cutting machines, levelers, and squaring shears, all with a capacity for 36" wide strip.

The cold rolling mills operated successfully from the start, producing cold rolled strip up to 36" in width, 24 gage and heavier, of the usual finishes, to which product the name "Stripsheets" was given.

In 1927 the Columbia Steel Co. was taken over by the American Rolling Mill Co., and in 1929 the latter company made extensive additions and improvements to the plant.

Three additional stands of four high cold rolls were installed, these being stands taken from the hot mill, where they had been replaced by somewhat larger and heavier equipment. The three stands

CHARACTERISTICS OF MILLS AND DRIVES

Mill	St.	ROLLS Diameter	ROLLS Length	F.P.M.	Dist. to Next St.	MOTORS H.P.	MOTORS R.P.M.	MOTORS Volt	MOTORS Cur.
Tandem	1	14"–30"	42"	52.6–105.2	22'0"	400	500–1000	600	DC
	2	14"–30"	42"	76.2–152.4	22'0"	400	500–1000	600	DC
	3	14"–30"	42"	87.8–175.6	22'0"	400	500–1000	600	DC
	4	14"–30"	42"	110.0–220.0	44'0"	400	500–1000	600	DC
Single	Coiler 5 Reel	14"–30"	42"	128–256	44'0"	400	500–1000	600	DC
Single	6 Reel	14"–30"	42"	132–264		400	500–1000	600	DC

FIG. 8—4 high Cold Strip Mill, American Rolling Mill Co., Butler, Pa.

were arranged as a two stand tandem, and a single mill, particularly for reducing hot rolled stock to the lighter gages, without pickling, the so-called "Red Mill." Fig. 8.

Fourteen stands of two high rolls, of the sheet mill cold roll type, were added, and arranged as three and two stand tandems, and as single mills, for skin rolling in short, sheet, lengths.

At the same time there were added:

Two continuous box annealing furnaces of the tunnel type.

Three blue annealing furnaces.

Three continuous picklers, and one tank pickler.

In the year following the installation of the cold strip equipment at the Butler plant, the American Steel & Wire Co., Cuyahoga Works, placed in operation a tandem train of four cluster mills, which, together with a single, two high mill, were equipped with anti-friction bearings.

The Trumbull Steel Co., at Warren, Ohio, and the Weirton Steel Co., Weirton, W. Va., also, each installed a cold rolling plant in connection with the broad, hot strip mills, which were, at that time, under construction.

The American Steel & Wire Co. installation and the Trumbull Steel Company installation, formed extensions to their existing plant, while the Weirton Steel Co., installation formed part of an entirely new plant. All three of these were for the purpose of handling strip in long coils.

In the same year, 1927, the Allegheny Steel Co. installed a four stand, four high, tandem train, and the American Rolling Mill Co., a five stand tandem train, both of which were designed for cold rolling sheets, in short lengths.

The Newton Steel Co., and the American Sheet & Tin Plate Co., each installed a single four high mill, and the United Alloy Steel Co., a single cluster mill, for the same purpose.

CHARACTERISTICS OF MILLS AND DRIVES

Mill	St.	ROLLS Diameter	ROLLS Length	F.P.M.	Dist. to Next St.	MOTORS H.P.	MOTORS R.P.M.	MOTORS Volt	MOTORS Cur.
	1	14"–32"	42"	89–178	22'0"	400	500–1000	600	DC
Tandem	2	14"–32"	42"	110–220	44'0"	400	500–1000	600	DC
	Coiler								
Single	3	14"–32"	42"	128–256		400	500–1000	600	DC
	Coiler								

American Steel & Wire Co., Cuyahoga Works

Following the International Nickel Co. mill at Huntington, the next installation of cold mills of the cluster type, and the first large cluster mills for rolling steel, was at the Cuyahoga Works of the American Steel & Wire Co. Cleveland, Ohio. The installation consisted of four cluster mills, of 32" roll face, arranged in tandem, with a reel following the last stand, and it was designed for rolling strip, in widths up to 28", in long coils. The mill went into operation in Jan. 1927. These mills were equipped with roller bearings on the backing rolls, as was also a two high mill, installed at the sametime. **Fig. 9.**

FIG. 9—Cluster Mill for Cold Strip, American Steel and Wire Company, Cleveland, Ohio.

CHARACTERISTICS OF MILLS AND DRIVES

Mill	St.	ROLLS Diameter	Length	F.P.M.	H.P.	MOTORS R.P.M.	Volt	Cur.
Tandem	1	10½"–21½"	32"	41.1– 82.2	250	400–800	230	DC
	2	10½"–21½"	32"	52.0–104.0	250	400–800	230	DC
	3	10½"–21½"	32"	70.4–140.8	250	400–800	230	DC
	4	10½"–21½"	32"	110–220	250	400–800	230	DC
Single	Reel	18"	32"	99–198	250	400–800	230	DC
	Reel							

Allegheny Steel Co.

One of the earliest concerns to consider the possibility of applying the four high, backing roll mill, to the field of sheet production, was the Allegheny Steel Co., Brackenridge, Pa.

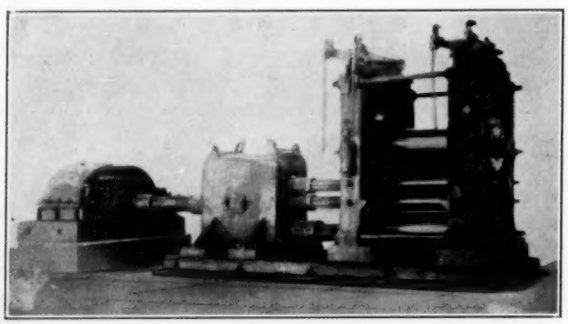

FIG. 10—Four High Cold Sheet Mill, Allegheny Steel Company, Brackenridge, Pa.

As early as 1923 this company built an experimental mill, the specific intention of which was to secure a greater percentage of cold rolling, on sheets in short lengths, than was obtainable on the regular sheet mill cold rolls, and to secure freedom from the grain enlargement, and the condition known as "Steads Brittleness" occurring when soft steel is box annealed after a small amount of cold work.

The experimental mill was constructed by taking a set of ordinary sheet mill housings, and adding two small rolls between the usual two large rolls, plain bearings being used throughout. The results obtained with this crude apparatus were such as to indicate the possibilities of the method, and in 1926, an order was placed with the Mackintosh Hemphill Co., for four stands of four high rolls, having antifriction bearings on the backing rolls. These mills were placed in operation in May, 1927, and have been in use continuously since that time, cold rolling sheets up to 42" wide. Fig. 10.

It may be noted from the illustration of these mills that they were designed to have the bottom backing roll driven, being provided with a third pinion and spindle. This provision was never found necessary, and only the working rolls are now driven. The mills also had the two screws usual in sheet mill cold rolls instead of the single screw now usual in four high mills.

During the past few years these four high mills have figured largely in the production of stainless steel sheets, in which product the Allegheny Steel Co. was one of the pioneers and for which the conventional sheet mill cold rolls were inadequate.

CHARACTERISTICS OF MILL AND DRIVE

Mill	St.	MILL Diameter	Length	F.P.M.	H.P.	MOTORS R.P.M.	Volt	Cur.
Tandem	1	12"–30"	50"	63–189	250	400–1200	230	DC
	2	12"–30"	50"	63–189	250	400–1200	230	DC
	3	12"–30"	50"	63–189	250	400–1200	230	DC
	4	12"–30"	50"	63–189	250	400–1200	230	DC

Trumbull Steel Co., Warren, Ohio (Warren Plant, Republic Steel Corporation)

In 1926, when the new broad strip was under consideration, the cold rolling plant of the Trumbull Steel Co. included rolling equipment for widths up to 22". In order to increase their range up to the capacity of the new hot mill, 32", they installed four stands of four high rolls, arranged as a tandem of three stands, and a single mill, and two stands of two high rolls for skin rolling. These mills were built by the United Eng. & Fdy. Co. and went into operation in May, 1927. Fig. 11.

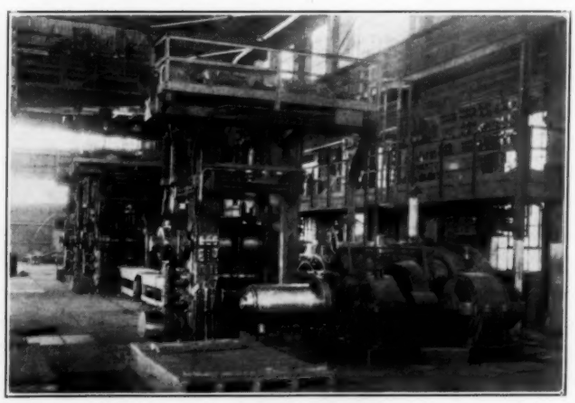

FIG. 11—Tandem Cold Strip Mill, Republic Steel Corporation, Warren, Ohio.

CHARACTERISTICS OF MILLS AND DRIVES

Mill	St.	ROLLS Diameter	Length	F.P.M.	Dist. to Next St.	MOTORS H.P.	R.P.M.	Volt	Cur.
	1	14″–32″	42″	78–156	20′0″	400	400–800	230	DC
Tandem	2	14″–32″	42″	93–186	40′0″	400	400–800	230	DC
Reel		16″	38″			75	225–900	230	DC
	3	14″–32″	42″	110–220		400	400–800	230	DC
Reel		16″	38″			75	225–900	230	DC
Single		14″–32″	42″	110–220		400	400–800	230	DC
Reel		16″	38″			75	225–900	230	DC
Single		20″	42″	153–308		200	400–800	230	DC
Reel		16″	38″			75	225–900	230	DC
Single		20″	32″	153–308		200	400–800	230	DC
Reel		16″	38″			75	225–900	230	DC

In addition to the new equipment, four stands of two high, 20″ x 24″ rolls were removed from the old, No. 1 cold mill to the new, No. 2 cold mill, for use on the narrower product, 8″ to 16″, of the rebuilt hot mill.

Extensive additions to the pickling and annealing equipment were made, including a new continuous pickler, for 32″ wide strip, and new box annealing furnaces.

In 1928 the company purchased one Steckel mill, and in 1929, a second larger mill.

CHARACTERISTICS OF MILLS AND DRIVES

Mill	ROLLS Diameter	Length	F.P.M.	MOTORS H.P.	R.P.M.	Volt	Cur.
Reel	22″						
Reversing	3″–24″	18″	0–450–1000	200	400–800	230	DC
Reel	22″						

MOTOR-GENERATOR SET

Motor: 225 KVA, .85 PF, 1200 R.P.M., 2200 V, 60 cy syn.
Gen: 165 KW, 250 V DC
Ward-Leonard Control

Reel	30″			500	400–900	230	DC
Reversing	5″–32″	38″	0–450-1000				
Reel	30″			500	400–900	230	DC

MOTOR-GENERATOR SET

Motor: 575 KVA, .80 PF, 1200 R.P.M., 6600 V, 60 cy syn.
Gen: 400 KW, 250 V DC
Ward-Leonard Control

The larger Steckel mill was never installed, as such, and in 1933, it was remodeled, the working rolls were increased in diameter to 10″, and it was changed over to the driven roll type, with a pinion stand and a gear reduction added. A 1000 H.P. motor was added to drive the rolls, the two 500 H.P. motors originally furnished to drive the mill, being used to drive the reels in the new layout.

CHARACTERISTICS OF MILL AND DRIVE

Mill	ROLLS Diameter	Length	F.P.M.	MOTORS H.P.	R.P.M.	Volt	Cur.
Reel	30″			500	400–900	230	DC
Reversing	10″–32″	38″	0–500–1000	1000	200–400	230	DC
Reel	30″			500	400–900	230	DC

MOTOR-GENERATOR SETS

Rolls—Motor: 1020 H.P., .60 PF, 900 R.P.M., 2200 V, 60 cy syn.
Gen: 750 KW, 250 V DC
Reels—Motor: 575 KVA, .80 PF, 1200 R.P.M., 6600 V, 60 cy syn.
Gen: 400 KW, 250 V DC
Ward-Leonard Control

Weirton Steel Co., Weirton, W. Va.

The initial cold rolling installation of the Weirton Steel Co. broad strip mill included two tandem trains of four stands each of four high rolls, one of 48" and one of 42" face, and two single stands of four high rolls, one of each width. Fig. 12.

In addition there were three stands of two high skin rolling mills.

In addition to the cold rolling equipment proper, there were installed, two continuous picklers, each having a capacity of one 48" strip, or the equivalent in narrower strips.

The annealing equipment comprised an original installation of eight double box, double row, annealing furnaces, since supplemented by eighteen additional furnaces of the same type, and two continuous normalizing furnaces. The normalizing furnaces are located in the bay containing the annealing furnaces, and on a floor above them.

Additional finishing equipment provided included, two combination flattening and cutting machines, slitters and edge trimmers, flatteners, and a patent leveler.

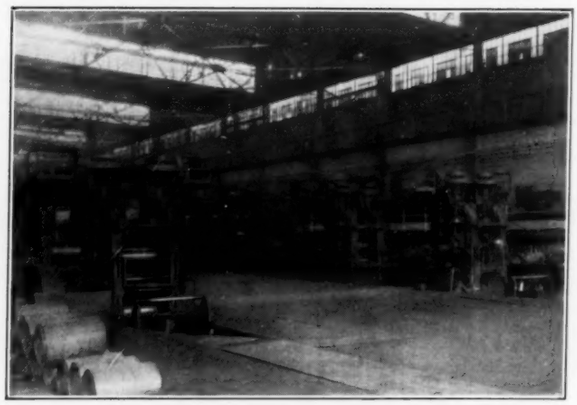

FIG. 12—Tandem Four High Cold Strip Mill, Weirton Steel Co., Weirton, W. Va.

The cold rolling department produces all grades of cold rolled strip, in widths from 12" to 24", and full finished auto body, metal furniture, and other sheets, up to 48", as well as tin plate made by the cold reduction process.

CHARACTERISTICS OF MILLS AND DRIVES

Mill	St.	Type	ROLLS Diameter	Length	F.P.M.	Dist. to Next St.	MOTORS H.P.	R.P.M.	Volt	Cur.
	1	4 Hi	14"–32"	48"	69.5–139	25'0"	500	400-800	600	DC
	2	4 Hi	14"–32"	48"	86–172	25'0"	500	400-800	600	DC
Tandem	3	4 Hi	14"–32"	48"	104–208	25'0"	500	400-800	600	DC
	4	4 Hi	14"–32"	48"	117–234		500	400-800	600	DC
	Reel		25"	44"			75	225-900	250	DC
	1	4 Hi	14"–32"	42"	69.5–139	25'0"	500	400-800	600	DC
	2	4 Hi	14"–32"	42"	86–172	25'0"	500	400-800	600	DC
Tandem	3	4 Hi	14"–32"	42"	104–208	25'0"	500	400-800	600	DC
	4	4 Hi	14"–32"	42"	117–234		500	400-800	600	DC
	Reel		25"	44"			75	225-900	250	DC
Single		4 Hi	14"–32"	48"	117–234		500	400-800	600	DC
	Reel		25"	44"			75	225-900	250	DC
Single		4 Hi	14"–32"	42"	117–234		500	400-800	600	DC
	Reel		25"	44"			75	225-900	250	DC
Single		2 Hi	20"	48"	130–390		150	400-1200	250	DC
	Reel		25"	44"			75	225-900	250	DC
Single		2 Hi	20"	48"	130–390		150	400-1200	250	DC
	Reel		25"	44"			75	225-900	250	DC
Single		2 Hi	20"	48"	130–390		150	400-1200	250	DC
	Reel		25"	44"			75	225-900	250	DC

In addition to the cold mills just described, there was installed in 1930, one Steckel mill of the larger size, 38" and in 1932, two additional smaller mills, one 20" and one 28".

CHARACTERISTICS OF MILLS AND DRIVES

Mill		ROLLS Dia.	Lgth.	F.P.M.	MOTORS H.P	R.P.M.	Volt	Cur.
	Reel	30"			500	400-900	230	DC
Non	Driven	5"–32"	38"	0–448–1010				
	Reel	30"			500	400-900	230	DC

MOTOR GENERATOR SET

Motor: 575 KVA .80 PF 1200 RPM 6600 V 60 cy syn.
Gen: 2–400 KW 250 V DC
Ward-Leonard Control

Non Driven	Reel Reel	3″–24″	20″	0–442–884	200	400-800	230	DC

MOTOR GENERATOR SET

Motor: 225 KVA .85 PF 1200 RPM 6600 V 60 cy syn.
Gen: 165 KW 250 V DC
Ward-Leonard Control

Non Driven	Reel Reel	5″–27″	28″	0–392–784	600	400-800	600	DC

MOTOR GENERATOR SET

Motor: 720 KVA .80 PF 900 RPM 6600 V 60 cy syn.
Gen: 500 KW 600 V DC.
Ward-Leonard Control

Newton Steel Co.

Another of the early concerns to experiment with the application of the four high roller bearing mill, to the cold rolling of sheets from the conventional hot sheet mill, was the Newton Steel Co., Newton Falls, Ohio.

In 1927 they obtained a four high mill which was operated in an experimental way for about a year, but the results were never made public, and the mill was eventually sold.

CHARACTERISTICS OF MILL AND DRIVE

	ROLLS			MOTOR			
Mill	Dia.	Lgth.	F.P.M.	H.P.	R.P.M.	Volt	Cur.
Single	14″-32″	48″	154-308	400	400-800	230	DC

Central Alloy Steel Co.

The next mill of the cluster type, and the largest of that type that has been built up to the present time, 54″, was installed by the Central Alloy Steel Co., at Canton, Ohio, in 1927. This mill was designed for the cold rolling of sheet lengths and was not provided with a reel. It has been largely used for the cold rolling of stainless steel sheets.

CHARACTERISTICS OF MILL AND DRIVE

	ROLLS			MOTOR			
Mill	Dia.	Lgth.	F.P.M.	H.P.	R.P.M.	Volt	Cur.
Single	14″-27″	54″	80-160	400	400-800	230	DC

American Rolling Mill Co., Ashland

The American Rolling Mill Co., since 1924, had been producing sheets from 18 to 24 gage, by hot rolling the rough sheets from the continuous sheet mill, and in 1927 they installed a cold mill with the intention of making an equivalent reduction, without

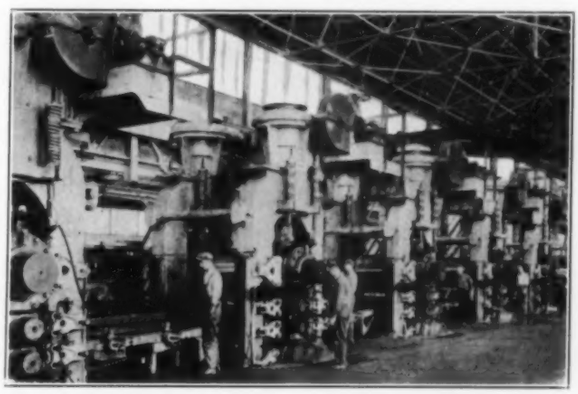

FIG. 13—Four High Cold Sheet Mill, American Rolling Mill Co., Ashland, Ky.

the necessity for reheating, and also with the expectation of making a more highly finished sheet, with improved physical qualities. Fig. 13.

The mill comprised five stands, of four high rolls, arranged in tandem, with room for a sixth stand, if

CHARACTERISTICS OF MILL AND DRIVE

		ROLLS				MOTORS			
Mill	St.	Diameter	Length	F.P.M.	Dist. to Next St.	H.P.	R.P.M.	Volt	Cur.
	1	14″–34″	58″	63.5–127	18′0″	600	400–800	230	DC
	2	14″–34″	58″	78.9–157	18′0″	600	400–800	230	DC
Tandem	3	14″–34″	58″	95.5–191	18′0″	600	400–800	230	DC
	4	14″–34″	58″	113–227	18′0″	600	400–800	230	DC
	5	14″–34″	58″	129–258		600	400–800	230	DC

2—MOTOR-GENERATOR SETS

Motor: 1440 H.P., .80 PF, 6600 V, 60 cy, 720 R.P.M. syn.
Gen: 1000 KW, 250 V, DC

such should later be required. The sheets from the continuous, hot sheet mill, at about 16 gage, are pickled and cut into lengths to produce a single sheet. These short lengths are carried on a traveling belt to the cold mill and entered into each of the five stands in succession, the piece never being in more than a single stand at the same time. Sheets are ordinarily reduced from 14 or 16 gage to 20 to 24 gage in the five passes. After cold rolling the sheets are box annealed and skin rolled on the sheet mill cold rolls.

Wheeling Steel Corporation*

Otis Steel Co., Cleveland, O.

The Otis Steel Co., in 1931-2, installed a cold strip mill that in size, and connected horse power, exceeded anything built up to that time. This mill was designed for the further cold reduction of the product of the 72" hot strip mill, then under construction.

The cold mill comprised two stands of four high rolls arranged in tandem. The first stand was equipped with a magnetic type uncoiler and feeder, and the second stand with a tension reel, equipped with automatic entering guides.

Each stand is driven by a 1500 H.P. motor, and the reel by a 400 H.P. motor. All three motors are driven from an independent motor generator set.

The entire mechanical equipment was built by the United Eng. & Fdy. Co. The weight of each roll housing is approximately 175,000 lbs., of each backing roll 66,400 lbs., of each working roll 10,000 lbs., and the weight of the mills complete, with rolls, pinions and pinion housings, gear reductions, reel and reel guides, and automatic uncoiler, is about 2,250,000 lbs. Figs. 14-15.

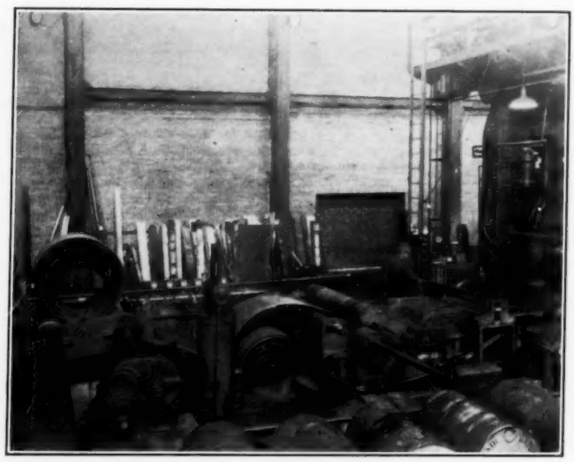

FIG. 14—Four High Cold Strip Mill, Otis Steel Co., Cleveland, Ohio. Entry Side.

CHARACTERISTICS OF MILL AND DRIVE

		ROLLS			Dist. to	MOTORS			
Mill	St.	Dia.	Lgth.	F.P.M.	Next st.	H.P.	R.P.M.	Volt	Cur.
Tandem	1	20"–52"	72"	101–202		1500	200-400	600	DC
	2	20"–52"	72"	155–310		1500	200-400	600	DC

MOTOR GENERATOR SET

Motor: 3570 KVA .80 PF 720 RPM 11000 V 60 cy Syn.
Gen: 2–1250 KW 600 V DC
Ward-Leonard Control

The mill was designed for cold reductions, up to 50%, on 60" wide stock, at a speed of 150 feet per min., and this has been readily accomplished. The mill is now producing all grades and finishes of full finished auto-body stock.

In addition to the cold rolling equipment proper, there is installed a continuous pickler, automatic flattening and cutting up machines, edge trimmer and slitter, and other auxiliary machinery. The existing sheet mill cold rolls are utilized for skin rolling, and the sheet mill annealing and normalizing furnaces for the heat treatment of the strip.

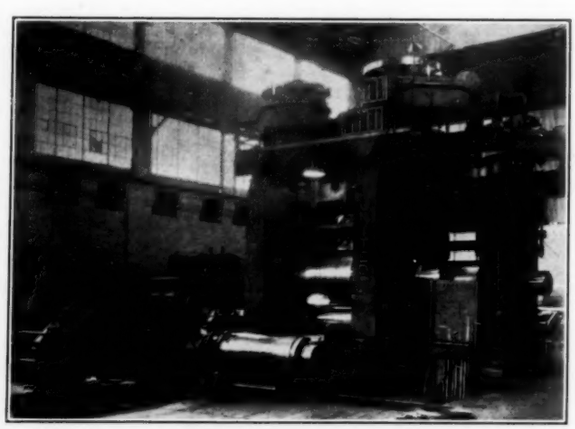

FIG. 15—Four High Cold Strip Mill, Otis Steel Company, Cleveland, Ohio. Delivery Side.

* The description of the Steubenville and Yorkville plants of the Wheeling Steel Corporation will be found on page 361.

Inland Steel Co.

In 1932 the Inland Steel Co. had completed and placed in operation a very complete installation of the broad strip type, and included therein was a cold rolling plant for the further reduction of the hot rolled product.

The cold rolling equipment included two tandem trains of three stands each, and two single stands, all with four high rolls. Each tandem train, with its reel, is driven from a separate motor-generator set equipped with Ward-Leonard control. The two single stands are driven from a third motor-generator set. In addition to the four high stands there are two two high mills for skin rolling, these being driven from the mill 250 volt line.

In addition to the roll trains there are two continuous picklers, two tunnel type box annealing furnaces, and eight batch type annealing furnaces, besides a very complete equipment of flattening and cutting up machines, levelers, edge trimmers and slitters, as well as other finishing equipment.

The entire rolling equipment, as well as much of the auxiliary machinery, was built by the Mesta Machine Co.

The principal characteristics of the mills and drives are indicated in the accompanying table.

CHARACTERISTICS OF MILLS AND DRIVES

Mill	St.	ROLLS Diameter	Length	F.P.M.	MOTORS H.P.	R.P.M.	Volt	Cur.
	1	20″–44″	54″		500	400–800	600	DC
Tandem	2	20″–44″	54″		500	400–800	600	DC
	3	20″–44″	54″	150–300	500	400–800	600	DC
	Reel				100–150	225–900	600	DC
	MOTOR-GENERATOR SET							
	Motor: 1400 KVA, PF, 6600 V, 25 cy, 750 R.P.M. syn.							
	Gen: 1250 KW, 600 V, DC							
	Ward-Leonard Control							
	1	20″–44″	42″		350	400–800	600	DC
Tandem	2	20″–44″	42″		350	400–800	600	DC
	3	20″–44″	42″	150–300	350	400–800	600	DC
	Reel				100–150	225–900	600	DC
	MOTOR-GENERATOR SET							
	Motor: 1400 KVA, PF, 6600 V, 25 cy, 750 R.P.M. syn.							
	Gen: 1250 KW, 600 V, DC							
	Ward-Leonard Control							
Single		20″–44″	72″	150–300	500	400–800	600	DC
	Reel				100–150	225–900	600	DC
Single		20″–44″	72″	150–300	500	400–800	600	DC
	Reel				100–150	225–900	600	DC
	MOTOR-GENERATOR SET							
	Motor: 1400 KVA, PF, 6600 V, 25 cy, 750 R.P.M. syn.							
	Gen: 1250 KW, 600 V, DC							
Single		27″	54″		60–125	225–900	230	DC
	Reel				60–125	225–900	230	DC
Single		27″	54″		60–125	225–900	230	DC
	Reel				60–125	225–900	230	DC

Prior to the construction of the continuous broad strip mill, the Inland Steel Co. had been a producer of sheets on the conventional sheet mills, but had not entered into the field of tin plate production.

In 1933 they decided to enter the tin plate field and purchased a Steckel mill for the production of strip for tinning, using the product of the hot, broad strip mill. This mill has just been installed, and is expected to go into operation in the present year.

The characteristics of the Steckel mill are shown in the table below.

CHARACTERISTICS OF MILL AND DRIVE

Mill	St.	ROLLS Diameter	Length	F.P.M.	MOTOR H.P.	R.P.M.	Volt	Cur.
	Reel							
Reversing		5″–34″	38″	0–750–1500	1000	400–800	600	DC
	Reel							
	MOTOR-GENERATOR SET							
	Motor: 1100 KVA, 1.00 PF, 6600 V, 25 cy 750 R.P.M. syn.							
	Gen: 750 KW, 600 V, DC Exciter: 40 KW, 250 V, DC							
	Ward-Leonard Control							

At the present time there is under construction, an additional tandem train, of five stands of 18"–49" by 42" four high rolls, and two single stands of 18"–39" by 42" four high rolls. The tandem train, and each of the single stands will be equipped with a tension reel.

American Sheet & Tin Plate Co.

The American Sheet & Tin Plate Co. has contributed much to the development of cold rolling, in the wider widths, first in the form of sheet lengths, and more recently in the form of strip. In 1927 they installed a 55" mill, and in 1929 an 84" mill for the cold reduction of sheets from the conventional sheet mills.

This company was one of the first to install a hot mill of the broad strip type, the 42" continuous strip mill at the Gary Tin Mills. In 1931 they installed a four high cold mill, of the non-reversing type, for the cold reduction of the product of this mill. In the present year this mill was converted to the reversing type and placed in operation, and a second mill of the same type was ordered and is expected to start operation shortly.

Two larger mills of the same type, for the production of sheets up to 72" wide, in coil lengths, have been built and are expected to go into operation before the close of the present year.

Wood Works

In 1927 the American Sheet & Tin Plate Co. ordered a single stand, four high mill, for the Wood Works, McKeesport, Pa. This mill was built by the E. W. Bliss Co., and was equipped with roller bearing on both the backing rolls and on the working rolls, and was the first application of roller bearings to the working rolls of a four high mill.

The mill went into operation in January, 1928, and was originally designed to cold roll low carbon sheets from the conventional hot mills. Lately, however, it has been used to roll stainless steel sheets as well. This mill was not equipped with a reel, as unnecessary for the short sheet lengths involved.

CHARACTERISTICS OF MILL AND DRIVE

	ROLL			MOTOR			
Mill	Dia.	Lgth.	F.P.M.	H.P.	R.P.M.	Volt	Cur.
Single	16"-34"	55"	102-204	400	400-800	230	DC

The mill motor derived its current from the main mill D.C. line and was not provided with a separate motor-generator set.

Mercer Works

In 1929 the American Sheet & Tin Plate Co. purchased for the Mercer Works, Farrell, Pa., what was the heaviest and widest, backing roll mill, for cold rolling purposes, proposed up to that time. It was designed for heavy cold reductions on low carbon sheets, up to 72" in width. The roller bearings, of the tapered roller type, had a radial capacity of 5,000,000 lbs. at a speed of 200 F.P.M., and were of the greatest capacity, for rolling mill duty, built up to that time.

This mill was built by the United Eng. & Fdy. Co. and first went into operation in November, 1929. Fig. 16.

This mill, like the Wood Works mill, was designed for cold rolling sheets in short lengths, and was not provided with a reel.

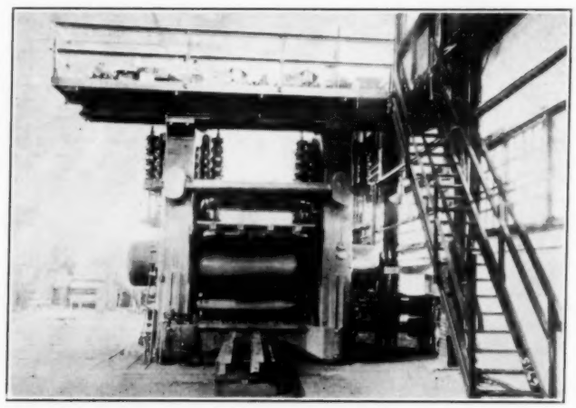

FIG. 16—Four High Cold Sheet Mill, Mercer Works, American Sheet & Tin Plate Company, Farrell, Pa.

CHARACTERISTICS OF MILL AND DRIVE

	ROLL			MOTOR			
Mill	Dia.	Lgth.	F.P.M.	H.P.	R.P.M.	Volt	Cur.
Single	16"-48"	84"	108-325	400	400-1200	230	DC

Gary Tin Mill

When it was decided to construct the continuous broad strip mill at Gary, two methods for the further reduction of the product to lighter gages were considered: First: The hot reduction of breakdowns, in short lengths, on the existing tin mills. Second: The cold reduction, in coil lengths, on mills of the four high type. The first alternative was the one adopted at the time, and some four years later, operations in line with the second alternative were begun, supplementing the production by the tin mills, from strip mill breakdowns.

Early in 1931 they ordered a four high cold mill for the further reduction of the hot strip, in coils of about 16 gage thickness, to tin mill gages. The mill was built by the E. W. Bliss Co., and went into operation in November of the same year.

As originally constructed the mill consisted of a single stand of four high rolls, with one tension reel and a feed reel equipped with dynamic braking generator. The rolls and the reel were each driven by a separate motor, and both motors were furnished with current from an existing motor-generator set.

CHARACTERISTICS OF MILL AND DRIVE

		ROLL			MOTORS			
Mill		Diameter	Length	F.P.M.	H.P.	R.P.M.	Volt	Cur.
	Feed Reel				Gen. 35			
Single		16"–46"	42"	200–400	675	400–800	600	DC
	Reel	24"			500	300–900	600	DC

The mill was operated for about eighteen months, in accordance with ordinary strip mill practice, removing the drum with the coil upon it from the reel after each pass, and produced strip for tinning in a generally satisfactory manner. A reduction of .062" hot strip 30" wide, to .011" in four or five passes, at speeds ranging from 200 F.P.M. for the first pass, to 400 F.P.M. for the last pass was considered usual practice.

An additional four high mill, for planishing, or skin rolling, in coils after annealing, was installed at the same time.

This mill was equipped with two reels, that on the entry side having a dynamic braking generator attached, for supplying back tension on the strip, and feeding back current to one of the two motors attached to the reel on the delivery side. The mill and the other reel motor, were driven from an independent motor-generator set.

CHARACTERISTICS OF MILL AND DRIVE

		ROLL			MOTORS			
Mill		Diameter	Length	F.P.M.	H.P.	R.P.M.	Volt	Cur.
	Feed Reel				Gen. 100 KW	600–1350	250	DC
Single		13"–27"	42"	0–400–800	150	300–900	230	DC
	Reel				200	300–1200	230	DC
					Regen. 125	600–1200	230	DC

MOTOR-GENERATOR SET

Motor: 225 H.P., .80 PF, 2200 V, 25 cy, 750 R.P.M. syn.
Gen: 150 KW, 250 V, DC Exciter: 15 KW, 250 V, DC
Ward-Leonard Control

In 1933 the mill was rebuilt, and changed to a two reel reversing unit, one reel on each side of the rolls, the strip being coiled on, and uncoiled from, the two reels alternately. It was first operated in its new form, in June, 1933.

The 675 H.P. motor on the main roll drive was replaced by a new motor of 1200 H.P., the old reel motor was used for one reel, and a new motor added for the other reel.

By avoiding the necessity for removing the coil from the reel after each pass, and with the higher power available it was expected that a considerable saving in labor, as well as an increase in production, would be accomplished. A concurrent advantage is that considerable tension may be applied to the strip on the entering, as well as on the delivery side, of the mill.

CHARACTERISTICS OF MILL AND DRIVE

		ROLL			MOTORS			
Mill		Diameter	Length	F.P.M.	H.P.	R.P.M.	Volt	Cur.
	Reel	30"			500	300–900	600	DC
Single Rev.		16"–46"	42"	0–500–800	1200	500–800	600	DC
	Reel	30"			500	300–900	600	DC

This mill was driven from the same motor-generator set, with Ward-Leonard control, enabling it to give a speed range from 0 to the minimum speed of the main roll and reel motors by generator voltage control. Speeds above the minimum are obtained by the usual motor shunt field control.

The ordinary practice on the rebuilt mill is to reduce strip 30" wide from .065" to .011" in three passes at a finishing speed of 500 F.P.M. for the first pass and 800 F.P.M. for the last pass.

A second mill of the single mill, two reel reversing, type, likewise designed for the production of strip, in coils, for tinning, has been ordered from the United Eng. & Fdy Co. and is about ready to go into operation.

CHARACTERISTICS OF MILL AND DRIVE

Mill		ROLL Diameter	ROLL Length	F.P.M.	MOTORS H.P.	MOTORS R.P.M.	MOTORS Volt	MOTORS Cur.
	Reel	30″			500	300–900	600	DC
Single Rev.		16″–49″	42″	0–500–800	1200	500–800	600	DC
	Reel	30″			500	300–900	600	DC

MOTOR-GENERATOR SET

Motor: 4300 H.P., .80 PF, 6600 V, 25 cy, 500 R.P.M. syn.
Gen: 2—1500 KW, 600 V, DC
Ward-Leonard Control

The motors of both this mill and the preceding mill of the same type, are driven from one 3000 KW motor-generator set in the hot strip mill, each mill having its separate 1500 KW generator.

Each mill has an independent control of speed from 0 to 500 F.P.M. by generator voltage control, and from 500 to 800 F.P.M. by motor shunt field control.

Gary Sheet Mill

During the present year the American Sheet & Tin Plate Co. has ordered and now under construction, two mills of the four high, backing roll type, that will exceed in size and weight anything previously constructed, either in the hot, or in the cold rolling field. One of these mills is being built by the E. W. Bliss Co., and the other by the United Eng. & Fdy. Co. The two mills are identical, as far as size of rolls is concerned, but are somewhat different in mechanical construction.

The mill built by the E. W. Bliss Co. has housings of the laminated plate, link type, with the screwdowns inside the housing windows, while the mill built by the United Eng. & Fdy. Co. is of the conventional type, with cast steel housings, and with the screwdowns passing through the upper part of the housings. Each of the roll stands will weigh about 1,500,000 lbs., a single housing alone weighing about 250,000 lbs. The Bliss mill was very adequately described and illustrated in the paper* by Mr. Lloyd Jones, formerly General Manager of the E. W. Bliss Co., at the meeting of this Society, in May, 1933, at Salem, Ohio.

Each of these mills will be of the single stand, double reel, reversing type, having the working rolls driven. The electrical equipment for each will form a complete independent unit, comprising: motor-generator set, main roll motor, and two reel motors. The general characteristics of the mills are given below.

The capacity of each of these mills is designed to be 50% reduction on .109″ thick strip, 72″ wide, at 250 F.P.M. and lesser reductions at increased speeds.

Neither of these mills is as yet, in operation, and data on their performance will be eagerly looked for.

There are two additional mills of the single stand, two reel reversing, driven roll, type now under construction. The one for the Jones & Laughlin Steel Co., at Aliquippa, and the other for the Youngstown Sheet & Tube Co., Indiana Harbor, both of which are designed for the production of strip in coils, for tinning.

These two mills and the mill recently installed by the Follansbee Bros. Co. mark the entry into the field of strip for tinning of concerns which do not, at the present time, possess broad strip mills, so that for the present at least, their raw materials will have to be provided by some modification of their existing mills, not strictly of the broad strip type, or by purchase from some outside source.

* This paper appeared in the August, 1933 issue of the Iron and Steel Engineer.

CHARACTERISTICS OF MILL AND DRIVE

Mill		ROLL Diameter	ROLL Length	F.P.M.	MOTORS H.P.	MOTORS R.P.M.	MOTORS Volt	MOTORS Cur.
	Reel				700	150–525	600	DC
Single Rev.		20″–56″	84″	0–250–500	1500	200–400	600	DC
	Reel				700	150–525	600	DC

MOTOR-GENERATOR SET

Motor: 2800 H.P., .80 PF, 2300 V, 25 cy, 500 R.P.M. syn.
Gen: 1750 KW, 600 V, DC Exciter: 50 KW, 250 V, DC
Booster Gen: 150 KW, 300 V, DC
Ward-Leonard Control

Youngstown Sheet & Tube Co., Indiana Harbor

The Youngstown Sheet & Tube Co. has operated a tinplate mill, of the conventional type, at the Indiana Harbor Works, since 1926.

In 1933 they supplemented this by a mill of the driven roll, reversing, type, for the production of strip for tinning by the cold reduction method. This mill is, in general, similar to the other mills of the type, built during the present year, both in construction, and in method of operation.

CHARACTERISTICS OF MILL AND DRIVE

		ROLLS			MOTORS			
Mill		Dia.	Lgth.	F.P.M.	H.P.	R.P.M.	Volt	Cur.
	Reel	30″			600	250–950	600	DC
Reversing		18″–49″	42″	0–667–1000	2000	232–348	600	DC
	Reel	30″			600	250–950	600	DC

MOTOR-GENERATOR SET

Motor: 2100 KVA .80 PF 514 RPM 11000 V 60 cy, syn.
Gen: 1500 KW 600 V DC Booster: 150 KW 350 V
Exciter: 75 KW 250 V DC
Ward-Leonard Control

Follansbee Brothers Co.

The Follansbee Brothers Co., with plants at Follansbee, W. Va., and Toronto, Ohio, had been for many years producers of both sheets and tin plate by the conventional methods, when in 1932, they decided to enter the field of the production of tin plate by the cold reduction method.

A large mill was ordered from the Cold Metal Process Co., which was installed in the early part of 1933 and first went into operation in July, 1933.

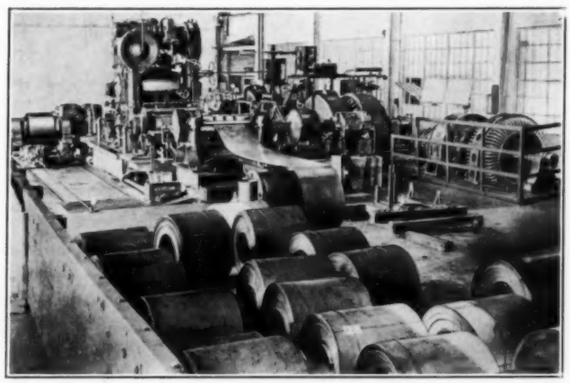

FIG. 17—Tin Plate Mill, Follansbee Brothers, Company, Follansbee, W. Va.

FIG. 18—Tin Plate Mill, Follansbee Brothers Company, Follansbee, W. Va.

The mill was of the four high type with non-driven working rolls. Figs. 17-18.

The hot rolled strip, in coils of about 6000 lbs. each, is reduced by successive passes on the cold mill, to tinplate gage without intermediate annealing. The direction of rolling being reversed between passes. When the strip reaches the desired gage,

CHARACTERISTICS OF MILL AND DRIVE

		ROLLS			MOTORS			
Mill		Diameter	Length	F.P.M.	H.P.	R.P.M.	Volt	Cur.
	Reel	28″	38″					
Non-Driven		5″–34″	38″	0–750–1500	1000	400–800	600	DC
	Reel	28″	38″					

MOTOR-GENERATOR SET

Motor: 1100 H.P., .80 PF, 2200 V, 60 cy, 900 R.P.M. syn.
Gen: 750 KW, 600 V, DC Exciter: 18 KW, 250 V, DC
Ward-Leonard Control

the winding drum with the coil upon it is transferred to a rewinder, upon which the coil, after the unreduced ends have been cut off, is rewound upon a collapsible drum, from which it is removed in the usual manner.

The coil is then moved by the crane to the entering end of a cleaning and cutting up line, which is located at right angles to the cold mill building. This line comprises:

First: A feed reel and stitching machine, in which the coils are unwound and the ends of successive coils placed one upon the other, and stitched, to permit continuous operation.

Second: A cleaning unit consisting of four tanks, the power washer, the electro cleaner, the scrubbing tank, and the hot water rinse tank.

Third: Following the cleaning unit, is a pinch roll, a side trimming shear for determining the width, a leveler and an end cut flying shear, for cutting the strip into the lengths desired for the finished tinplate.

The cleaning unit is about 60 feet in length, of which the electro cleaning tank occupies 33 feet. The first unit, the power washer, comprises a tank containing an alkaline cleaning solution, maintained at a temperature of approximately 160 degrees F., which, aided by brushes and a high pressure spray, removes the heavier deposits of oil and grease. Following the power washer the strip passes into the electro cleaning tank, which is of Meaker type and also contains an alkaline solution, maintained at a temperature of 160 degrees. The tank forms the anode, and the strip the cathode, for an electric current of approximately 4000 amperes at 6 volts, the current being conducted to the strip by means of ½" rings, which ride lightly on the top of the strip. Electro cleaning is done in a manner similar to that used in electro plating, the current passing through the alkaline solution liberating hydrogen gas at the cathode, in this case the strip, the hydrogen bubbles formed forcing all the remaining oil and grease from the pores of the metal.

The entire arrangement which was furnished by the Mesta Machine Co. is remarkably effective for the purpose for which it was designed.

The cut lengths of strip from the flying shear are transferred on a gravity conveyor to the annealing department, where they are box annealed in the regular tin mill annealing furnaces, and are then skin rolled and white pickled, and pass to the tinning pots, the assorting and packing rooms, and the warehouse.

Technique

To summarize the present practice in cold rolling broad strip, we may say that there are four different systems, all of which have one feature in common, that is, the use of four high, backing roll mills, equipped with anti-friction bearings. These systems are:

First: The system based upon the pre-existing wide strip mills, using long coils, either by tandem train, or by single mills. In the former case the system is characterized by the use of from two to five stands, arranged in tandem, one pass being made in each stand, and the piece being engaged in all stands at the same time. Following the last stand is a tension reel, or in some cases a coiler. Tension is commonly employed between the stands, as well as between the last stand and the reel, although this is not always the case. The speeds were comparatively slow, that of the last stand being commonly from 200 to 300 F.P.M., and that of the earlier stands being of the order of one-half of this. In the earlier mills the drafts were generally light, seldom exceeding 30% in any one stand, or 60% in the tandem train, but now the drafts have generally been revised upward, a total reduction of 70 or 90% not being uncommon, particularly when producing strip in tinplate gages.

Examples of the tandem type may be found in the earlier mills, Butler, Cuyahoga, Trumbull and Weirton. Later built mills of the type are the Steubenville and Yorkville mills of the Wheeling Steel Corporation and the Inland Steel Co. mill.

In the case where single mills are used, reduction is effected by successive passes in the same stand provided with a reel, the coil being removed from the reel after each pass. Otherwise the characteristics are the same as in tandem operation.

Tandem trains are often supplemented by one or two single stands, in which the roughed down coil may be given an additional leveling pass. This, and their use for skin rolling or planishing stands is about the only place they are found in use today.

Second: The system based upon the pre-existing sheet mill practice, with the use of backing roll mills either in tandem train, or by single mills. In both cases the system is characterized by rolling short sheet lengths the piece being engaged by only a single stand at the same time, and always maintained flat and not coiled. Tension is, of course, impossible. The speeds of the stands are of the same order as those of the mills in the former system. Drafts are generally less than in strip rolling, seldom exceeding a total of 50% in four or five passes.

In the case of the single mill, a considerable number of sheets are each given a single pass through the stand, and then returned to the entry side, and given a second pass, and so on. The single mill type has probably found its widest use in the production of sheets of the corrosion resisting alloys of chrome and chrome nickel, stainless steels and rustless iron.

Of the tandem type we have the mills of the Allegheny Steel Co., and the Ashland mill of the American Rolling Mill Co. Of the single mill type there are the mills of the International Nickel Co., at Huntington, W. Va.; the United Alloy mill, at Canton, O., and the American Sheet & Tin Plate mills at the Wood Works and at the Mercer Works.

Third: The Steckel system. This system uses strip in long coils, the entire reduction being carried on by successive passes in the same stand, the direction of rolling being reversed between passes. This system is characterized by the use of exceedingly small rolls, from 2" to 5" in diameter, backed up by much larger rolls, from 24" to 36" in diameter. The rolls are not in themselves driven, all the power being applied through tension exerted on the strip, by the reels.

The mill is equipped with two reels, one on each side of the mill, upon which the strip is alternately

coiled and uncoiled. The ends of the strip are, at all times, retained on both reels, the unreduced ends being subsequently removed by cropping. The speeds are high, running up to 1500 feet per minute, or more. The drafts are generally light, not usually greater than 15%. Fig. 19.

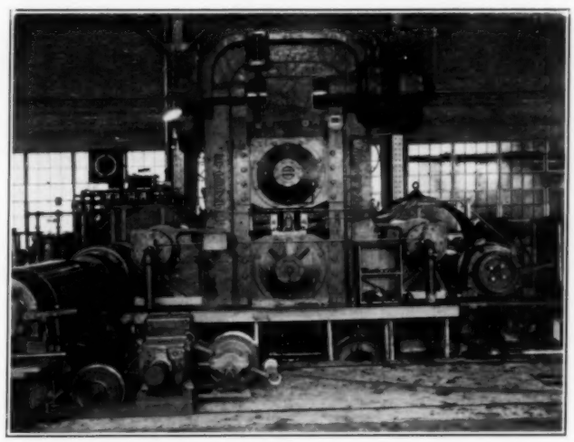

FIG. 19—38" Steckel Mill

These mills in the past, have been small, not exceeding 20" capacity until 1929, but there are now two of 38" width in operation, one at the Weirton Steel Co., and one at the Follansbee Brothers Co. A third, that of the Inland Steel Co., is about ready to go into operation.

Fourth: The single mill, driven roll, reversing system. This system has been in use in Europe for a number of years, but has only come into use in this country during the year past. It is now seeing a tremendous expansion, two mills of the type now being in operation, and five mills under construction.

The system is characterized by the use of the four high mill, having working rolls and backing rolls of the usual proportions, and with the working rolls driven. It is equipped with two reels, one on each side of the mill, each having its separate motor drive. There are thus three main motors on the mill, one on the rolls proper, and one on each of the two reels. Each reel motor is commonly of one-half the H.P. of the main roll motor. All motors are driven from a single M.G. set, or from a separate M.G. set for the main rolls and for the two reels.

This system features the combination of heavy drafts with high speeds, together with the application of tension on the strip, both on the entering and on the delivery sides. The direction of rolling is reversed between passes. As in the case of the Steckel mill the ends of the strip are retained on both reels until the rolling of a coil is completed, there is therefor a length of strip at each end of the coil of the initial thickness, which must be removed and scrapped, or otherwise disposed of. It can readily be seen that the percentage of waste from this cause decreases as the weight of the coil increases, or for equal weight coils, as the initial thickness is less. Carried to its extreme, this would indicate that for maximum economy, a coil of the full weight of the ingot would be required.

Skin Rolling

The foregoing paragraphs relate primarily to the reduction of the hot rolled strip, or sheet, to approximately the gage of the finished product, rolling for reduction. There is a second type of rolling, rolling for temper, which is characterized by somewhat different methods.

Rolling for temper is required when a physical condition, intermediate between the hard rolled condition, resulting from a drastic cold reduction, and the dead soft condition, obtained by annealing the cold rolled material, is required. This is commonly effected by an additional cold rolling, after annealing, of the order of from 3% to 20%, according to the final temper desired. As far as broad strip is concerned, the rolling for temper is generally limited to the lower portion of this range, quarter hard and skin rolled.

When cold rolled strip is box annealed, dead soft, it has the property of taking a so-called "set", if it is bent beyond a certain point, the metal not returning to its original physical condition, and the surface is marked by cross breaks, or wrinkles, or as they are termed in the finished product, "stretcher strains". When the dead soft strip is afterwards subjected to a considerable amount of cold working, as for example, a deep drawing operation, the cross breaks disappear, but if the cold working is light, or if there are extensive lightly worked surfaces, in some parts of a deep drawn article, the cross breaks are highly objectionable.

For these reasons most cold rolled broad strip is given an additional reduction, after annealing. This cold rolling is known as, skin rolling, pinch rolling, and planishing, and serves the purpose of preventing the formation of cross breaks, or stretcher strains, without greatly increasing the hardness, or injuring the drawing qualities.

Skin rolling is accomplished by giving the strip a light reduction, of the order of 1% to 3%, either in the coil form, or in short, cut lengths. It is generally effected in two high mills, the slight reduction, and the low screw pressure required, not demanding the use of the stiffer, four high, mills. When skin rolled in coils the mill is, of course, equipped with a reel, but when skin rolled in cut lengths, a mill without a reel is sufficient, and this is generally of the ordinary two high sheet mill, or tin mill, cold roll type, the cut lengths generally being transferred to existing sheet mill, or tin mill, cold rolling departments, and handled exactly as the sheets, or black plate, are handled.

In some few cases four high mills have been installed for skin rolling purposes, but at least as yet, it seems questionable whether the four high mill is more satisfactory for the purpose than the two high mill, and it is probable that the larger rolls, of the two high mills, are really more effective than the smaller rolls, of the four high mills.

Speeds and Drafts

The broad strip practice, like the narrower strip practice from which it was derived, shows a wide variation in the drafts and speeds employed. In general heavier drafts and higher speeds are employed than was the case in the narrower widths.

This may be explained by the fact that the weight and stiffness of the mills, due to the four high construction, has been increased in much greater proportion than the increase in width.

Drafts and speeds show an inter-relation, that is to say, as a rule, the heavier the draft, the lower the speed, and vice-versa. The relation of the drafts in successive passes shows wide differences in different plants, for example it may be the usual practice in one plant to use a heavy reduction, of the order of 50%, in the first pass, while another mill will regularly use a comparatively light draft, of the order of 25%, with the idea of closing the open surface of the pickled strip before beginning the heavy reductions. In almost all cases the second pass is given with the heaviest reduction possible. The last pass is generally driven with a less drastic reduction, as conducive to a flatter delivery.

With the present trend towards the combination of high speeds and heavy drafts it is almost imperative that some means be adopted to dissipate the heat evolved by the mechanical work, and this is being accomplished by various systems of flood lubrication. At the present time the preference is given to the use of some form of water soluble oil, of the general nature of cutting compounds, which serve the combined purpose of cooling and of lubricating the strip and the surface of the rolls.

Lubrication

The use of lubrication, between the strip and the roll surface, is another matter that shows a wide variation in practice. It may run all the way from entire absence of lubrication, dry rolling, through the use of water, to the use of a high grade lubricating oil.

Recent researches have indicated that the power required for cold rolling is greatly reduced by proper lubrication of the surfaces of the strip and of the rolls acting upon them, and for this reason rolling in oil is generally employed, unless the requirements as to finish are such, that it is obtainable only, without the use of oil.

In some plants it is usual to employ a straight mineral oil, while in others a mineral oil compounded with a saponifiable oil, such as lard oil, or wool, grease is used. The mineral oils used may vary from coal oil, or kerosene, to a medium lubricating oil. In general, it may be said that in all cases where the drafts are heavy the use of an oil with considerable lubricating quality is required. In the case of the first pass, on pickled stock, mentioned above, this is in some cases made dry, and in other cases with water on the strip. After the surface is once formed the use of a lubricant is general. When skin rolling, after annealing, all four methods are used, rolling with lubricating oil, with coal oil, with water, and dry. The latter two tend to give a harsher and brighter finish while the lubricating oil tends to a softer, satiny finish.

Tension Rolling

It is a well known fact that, in cold rolling strip, there are always minor inaccuracies present, in the piece, and in the shape of the rolls, the effect of which is to prevent a perfectly straight and flat delivery of the finished strip.

These inaccuracies may be in the form of gage variations, either transverse or longitudinal to the strip, or in the contour of the active pass of the rolls. They may be extremely small in magnitude and their effect upon heavy strip, or with light reductions, may be unnoticeable, but when the strip is thin, or the reductions heavy, they may become of considerable importance.

It is also a well known fact that the application of tension to the strip, on the delivery side of the mill, has a tendency to eliminate, or minimize, the effect of these irregularities, and to secure a straight and flat delivery of material that otherwise would be buckled or wavy, or curved and having a tendency to run to the ends of the rolls. This applies to tension exerted by a reel, as well as tension maintained between the several stands. More recently it has been found that the application of tension on the entry side of the mill, back tension, has the effect of still further eliminating the result of these irregularities.

The inability to supply tension to a short piece is probably sufficient explanation of the difficulties encountered in the cold rolling of short sheet lengths, with heavy reductions.

The principle of rolling under tension has been utilized to its fullest extent in the Steckel Mill, where the entire force applied to the reduction of the piece is exerted through tension on the strip, the rolls themselves forming what might very properly be called a rotary die. The same principle is applied to a lesser extent in the newer mills, of the single stand, reversing, driven roll type, in which a portion only of the power required is applied through tension exerted on the strip, and the greater part applied through the rolls.

The application of tension in rolling implies the use of stock in comparatively long lengths, otherwise the end of the piece between the rolls and the tension device whether a reel, or other mechanism, and upon which tension is absent, would form too large a proportion of the whole length of the piece. In modern practice the use of strip, in long coils, with heavy reel tension, has become general, and is an essential factor in the successful cold rolling of the wider widths.

The amount of tension, on the delivery side, may be of the order of 1000 to 2000 lbs. per inch of width, and the back tension is usually about one-half this amount, although at times, it may even exceed the delivery tension. The amount of tension is commonly greatest in the earlier passes, and is decreased as the piece becomes thinner, in order not to exceed the ultimate strength, and pull the piece apart. This implies a very close regulation of the tension reel motor, and it has been very effectually accomplished, both in the mills of the Steckel type, and in those in which only a portion of the power is applied through the reels.

Annealing and Finishing

The eventual use of the cold rolled product of the broad strip mill is usually for some product requiring a drawing, or forming, operation, that is to say, in the dead soft, or in the skin rolled condition. The practice, therefore, is first a rolling for reduction, generally of the order of 50 to 90%, followed by box annealing at a comparatively low temperature

to avoid sticking together of the layers, this being possible without excessive grain growth, on account of the high percentage of cold working.

At this point we find a variation in practice. In the one case the cold rolled material, in the hard state, is cut into sheet lengths, annealed in the flat, and then either shipped in the annealed state, dead soft, or given a skin rolling pass, in short lengths, on the ordinary sheet mill cold rolls, generally roller leveled, and sometimes resquared. In the second case the cold rolled material is annealed in coils, given a skin rolling pass on a mill equipped with a reel, then cut to length and flattened.

For certain purposes, particularly when a combination of unusual surface and drawing qualities is required, the material may be subjected to a normalizing heat treatment, either in place of, or in addition to, the usual box annealing.

In such cases the cold rolled strip may be cut up, and passed through the usual type of normalizer, in packs, or it may be passed through a shorter furnace, in continuous lengths, in single thickness.

In either case, the material is given a light pickling, if required, which may, or may not, be followed by further cold rolling, or by box annealing.

The material so treated should possess the fine, equi-axed grain structure characteristic of the normalized product.

When accurate widths are required, the coils are generally edge trimmed, in a rotary slitter, before annealing.

Production of Auto-Body Sheets

At the time that the Butler mill went into operation the use of full finished sheets, for auto body work, was showing a tremendous increase, and the body makers were demanding wider and wider sheets. At this time the sheet mills were furnishing full finished sheets up to 54" wide, and the trade was already demanding 60" and even 66" sheets.

Fender strips had already passed the 24" limit of the two high strip mills, and much of this business had been lost to strip and passed to the sheet mills.

When the Butler, Trumbull, and Weirton mills went into production they took a share of the wide fender strip business, and also such part of the auto-body stock requirement as was within their capacity, about 48", in the case of the Weirton mill. The wider sheets, necessarily, still had to be made on the conventional sheet mills.

It was natural that the sheet producers should consider the possibility of finishing these wider sheets by the cold reduction process and the American Rolling Mill Co. put in the 58" tandem cold mill, for the further cold reduction of the rough sheets from their continuous sheet mill at Ashland.

At about the same time the American Sheet & Tin Plate Co. put in their 55" wide four high mill, and the Central Alloy Steel their 54" Cluster mill, both of which were used for the partial cold reduction of full finished sheets. In the meantime the sheet mills had increased their widths to the 66" demanded, and in one case had gone to 72". At this stage the American Sheet & Tin Plate Co. put in the 84" four high mill at the Mercer Works. These three mills were all designed for use on short, sheet lengths, rather than on coils.

In 1932 the 72" Otis hot strip mill and the 76" Inland hot strip mill both went into operation, and it then became possible to obtain hot rolled strip, in coils, in 66" widths from the former mill, and in 69" widths from the latter mill. In the same year the Otis company put into operation their 72" wide cold strip mill making it possible to obtain full finished strip, in long lengths, up to 66" in width.

In 1931 the Illinois Steel Co., at the South Chicago Works, had installed the 96" continuous plate mill, and almost immediately after it started consideration was given to the idea of converting it into a strip mill. As originally built the Chicago mill was not intended to roll gages less than ⅛" and equipment was provided for handling the product in straight lengths only. It was suggested that, by the addition of one or two additional stands of rolls, and a hot coiler, that this mill could be converted into a mill capable of rolling strip, in coils, up to 90" in width.

In 1932, with this possibility of obtaining coils wider than any then obtainable, the American Sheet & Tin Plate Co. ordered two 84" four high cold mills that would produce by the cold reduction process, in long coils, full finished auto body sheets of any width, up to the maximum produced in short lengths on the conventional sheet mills. These mills were designed to operate on the single stand, reversing, driven roll system as described previously.

Production of Tin Plate

The production of tin plate by a cold reduction process is a subject that is of particular interest at the present time.

For many years, tinned narrow strip, or flat wire, had been produced in this country, and abroad. In Germany particularly, tinned strip up to about 9" in width had been produced.

With the tremendous increase in the consumption of tin plate by the canning industry, which occurred in the decade from 1900 to 1910, the field for tinned strip, up to 7" in width seemed to be a promising one, but for various reasons it never gained a foothold, and it has been only within the last few years that the production of strip for tinning has assumed any importance in the trade.

In 1928-9 the problem of producing strip for tinning again came to the front. It was attacked by two companies, at least, both of whom used the Steckel mill for the purpose. While the production of strip, of the desired width and gage, presented no great difficulties, the tinning of the strip, in long coils, proved unsuccessful.

The first commercial production of tin plate, by a cold reduction method, was at the Yorkville plant of the Wheeling Steel Corporation in 1930. The development took the form, not of the production of tinned strip in coils, but of a substitution of cut lengths of finished cold rolled strip, for the black plate made by the conventional methods.

The method here employed comprised, cold reduction of the pickled hot rolled strip, in a tandem train of four high rolls of the usual type, annealing, skin rolling, cleaning and cutting to length, and tinning in the conventional manner.

Similar methods were developed at other plants, four high mills being used, either in tandem train, or by successive passes in a single stand. In some cases the cold rolled strip was cut to length, then box annealed in the tin mill annealing furnaces, and cold rolled on the tin mill cold rolls, white pickled, and tinned in the usual short lengths.

One of the factors influencing the development of the Steckel mill, was the production of strip for tinning, and with the construction of the first narrow mills, as well as the later wider mills, this object was continually in the picture. The real entry of the Steckel mill into the commercial production of strip for tinning, was in 1931, one plant having been operating a 38" Steckel mill, practically exclusively for the production of tin plate since that time and having later purchased two additional Steckel mills for the same purpose.

In the present year the Follansbee Bros. Co., at their Follansbee Plant, has commenced the production of tin plate by the cold reduction method, using a Steckel Mill.

The Inland Steel Co., Indiana Harbor, Ind., has also installed a Steckel Mill, which is just about ready to go into operation.

During the past year considerable interest has been aroused in the production of tin plate, by the cold reduction, method, using the single stand, reversing mill, having driven working rolls. Exceptionally heavy drafts are employed, and at high speeds. Heavy tension is maintained upon the strip, both on the delivery side, and on the entry side, of the mill.

This system combines the advantages of high production with a minimum of manual labor, and as well as can be judged from a somewhat limited experience to date, the finish and the physical characteristics of the product are satisfactory. In general it seems to show some advantages over the earlier methods.

There are now five mills of this type, for the production of strip for tinning, either in operation, or about to go into operation, two at the Gary Tin Mill of the American Sheet & Tin Plate Co., one at the Warren plant of the Republic Steel Corp., one at the Aliquippa Works of the Jones & Laughlin Steel Corp., and one at the Indiana Harbor plant of the Youngstown Sheet & Tube Co.

The latter two mills, and the mill recently installed by the Follansbee Bros. Co., mark the entry into the field of strip for tinning by concerns which do not, at present, possess broad strip mills, so that for the time, at least, their raw materials will have to be provided by some modification of their existing mills, not strictly of the broad strip type, or by purchase from some outside source.

Character of Product

The Broad Strip Mill has proved itself capable of producing hot rolled steel of a quality and finish in every way comparable with that of the conventional plate mill, and of the narrower strip mill, as well as that portion of the product of the conventional sheet mill, within its gage range.

This applies not only to the ordinary grades of soft open hearth steel, but also to the alloys of the chrome and chrome nickel types, stainless steels and rustless irons. So-called "pure irons," low in impurities, such as Armco Iron and Toncan Iron, have been successfully rolled in the form of broad strip, when due consideration has been given to providing means for allowing the partially rolled material to cool through the critical range, prior to finishing.

Electrical sheets, (silicon steel) have not as yet been made by the broad strip process, although the same material in narrower widths, electrical strip, has been so made.

The cold rolled product of the broad strip mill competes successfully today with every product of the full finished sheet mill.

In general it may be said that both the hot and cold rolled product, made by the broad strip process, are of a better and more desirable finish, and are more accurate to gage, than the corresponding products of the conventional sheet mill. The drawing qualities may be different, not so much that they are inferior, as that difficulties are encountered when the attempt is made to form them on dies designed for conventional sheets. Such dies would necessarily require some changes to adapt them to the strip rolled product.

As an example of the adaptability of the product of the broad strip mill, it may be mentioned that one of the popular priced automobiles on the market today, has its entire flat rolled steel requirements, made by the continuous process.

The tin plate product, made by the cold reduction process, is today considered in most ways equal to, and in many ways superior to, the product of the old style tin mill. In the manufacture of tin plate by the conventional methods it has been found necessary to raise the phosphorus content to about .050%, in order to prevent the sticking of the pack during hot rolling. This is unnecessary for tin plate made by the cold reduction process, and for purposes involving a forming, or drawing, operation, the latter has found a field that is quite its own.

The technical advances in the manufacture of flat rolled steel have been reflected in the market price, the decrease in which has been much more than that of other products in which the technical advances have not been so marked.

For example, auto body sheets have dropped in price from 6.85 cents per lb., in 1920 to less than 2.30 in June of the present year, a fall of 66.5%. Hot rolled strips dropped from 5.50 to 1.40 in the same period, a fall of 74.5%. These figures may be compared with the composite rolled steel price of 4.00 cents in 1920 and 1.90 in 1933, a fall of 52.5%.

In the case of flat rolled steel products practically all of the benefits due to improved technique, have been passed on to the customer in the shape of lowered prices.

Wheeling Steel Corporation, Steubenville Plant.

The Wheeling Steel Corporation, had been, for many years, a producer of sheets and tin plate by the conventional methods and, when in 1927, it was planned to install a mill of the broad strip type, it was designed to produce hot mill breakdowns for the existing sheet mills, and also to furnish coils for further cold reduction to sheet and tin plate gages.

The cold rolling plant, at Steubenville, was built in 1928-9 and first went into operation in the latter year. The cold mills included seven four-high stnds, arranged as two tandem trains, of three stands each, and a single stand. In addition to the four high stands there were two two-high stands, for skin rolling, 2 continuous picklers, box annealing furnaces, and the necessary flattening, leveling and cutting up equipment.

CHARACTERISTICS OF MILLS AND DRIVES

Mill	St.	ROLLS Dia.	Lgth.	F.P.M.	Dist to next st.	MOTORS H.P.	R.P.M.	Volt	Cur.
	1	20″–44″	48″			500	250–750	250	DC
Tandem	2	20″–44″	48″			500	250–750	250	DC
	3	20″–44″	48″			500	250–750	250	DC
Reel						40–100	225–1125	250	DC
	1	20″–44″	48″			500	250–750	250	DC
Tandem	2	20″–44″	48″			500	250–750	250	DC
	3	20″–44″	48″			500	250–750	250	DC
Reel						80–130	225–1125	250	DC
Single		20″–44″	48″			500	250–750	250	DC
Reel						40–100	225–1125	250	DC
Single		27″	48″			150	250–750	250	DC
Reel						40–100	225–1125	250	DC
Single		27″	48″			80–130	225–1125	250	DC
Reel						80–130	225–1125	250	DC

Wheeling Steel Corporation, Yorkville Plant

The Yorkville plant of the Wheeling Steel Corporation had been producing tin plate by the conventional methods since 1912, and soon after the starting of the broad strip mill, at Steubenville, plans were made for the production of tin plate by the cold reduction method. The first commercial production, by the new method, was in 1930.

The cold rolling equipment provided for the purpose comprised five stands of four high rolls, arranged as a tandem train of four stands, and a single mill. In addition there is a single stand of two high rolls.

The practice, when rolling strip for tinning, is to start with hot rolled coils, of about 28″ in width, by .062″ gage from the broad strip mill, at Steubenville. At Yorkville the strip in coils is pickled and cold rolled in four passes to the desired gage, box annealed and skin rolled. It then passes to a cleaning line, comprising washer, electro-cleaning tank, and scrubber, followed by a flying shear where it is cut into the usual tin plate lengths. These short lengths are tinned in the usual manner. The product is marketed under the trade name of "Ductilite".

The cleaning line was the first of its kind to be built, and a fuller description will appear under the heading of the Follansbee mill. The entire cold rolling equipment was built by the Mesta Machine Co.

CHARACTERISTICS OF MILLS AND DRIVES

Mill	St.	ROLLS Dia.	Lgth.	F.P.M	Dist to next st.	MOTORS H.P.	R.P.M.	Volt	Cur.
	1	18″–30″	32″			235	325–975	230	DC
	2	18″–30″	32″			235	325–975	230	DC
Tandem	3	18″–30″	32″			235	325–975	230	DC
	4	18″–30″	32″	115–345		235	325–975	230	DC
Reel						27–80	130–1000	325	DC
Single		18″–30″	32″	115–345		235	325–975	230	DC
Reel						27–80	130–1000	325	DC
Single		27″	48″			235	325–975	230	DC
Reel						27–80	130–1000	325	DC

Reel motors driven from generator coupled to mill.

Controlling Screw-Down Drafts To The Exact Specifications of The Mill Superintendent

By D. C. WRIGHT,
Chief Engineer, The Electric Controller & Manufacturing Company, Cleveland, Ohio.

Presented before the Electrical Engineering Division of the A. I. & S. E. E. at the Twenty-ninth Convention in Pittsburgh, October 17, 1933.

The quality of the steel in any finished product is, to a large extent, determined by the quality of the product of the Blooming or other Roughing Mill which does the first rolling operation after the ingot has been taken from the soaking pits. The strength and proper alignment of the fibers of the steel may be greatly impaired by improper drafts at high temperatures. Also, seams and surface cracks are caused by undue stretching, and these must be removed by chipping the cold billet before it can be rolled to the final product. The cost of chipping varies in different plants, but an average of $1.00 per ton might be taken. In a larger mill the chipping costs may run into thousands of dollars per year, to say nothing of the investment costs of the chipping or deseaming equipment.

The Mill Metallurgists and Engineers are cognizant of these facts and spend a great deal of study on proper amount of draft, proper number of drafts, and proper rolling temperature for each size of bloom to be rolled for each size of billet and for each alloy. The rolling schedule is fixed by them and is supposed to be followed by the screw-down operator. But, are they followed correctly and precisely? The screw-down operator is human and without automatic aids, "following the schedule" is left up to his intelligence, his skill, his judgment, and his strength. It is true that he is given an indicator gauge which shows the exact separation of the rolls. But is he intelligent enough to **always** remember each draft for each pass for the many sizes of ingots and billets encountered in some mills? Is he skillful enough to set the gauge for proper draft without delaying the operation of the manipulator operator and main roller? Does he care to "hit the Bull's eye" exactly, particularly at the end of a long day when he is tired and the other operators are commenting on a short day's tonnage? Is he a new operator just breaking in? (There must be a lot of them in these first days of N. R. A.) If so, he can do a lot of damage, not only to the steel product but to the mill itself. Expensive main rolls, or even mill housings, have been broken by abnormal drafts, to say nothing of loss of production.

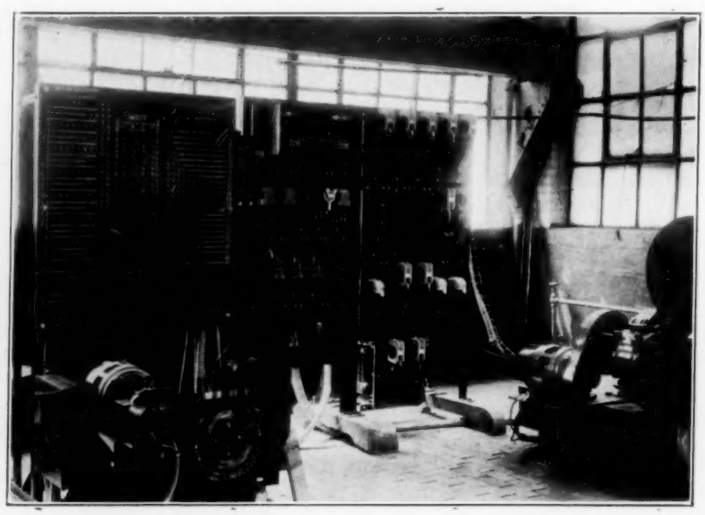

FIG. 1

For the above reasons, there is a growing demand for a type of screw-down control which will eliminate the "personal element" of the operator. An Automatic Pre-set Control will do this. All the operator has to do is to start the motor by means of a push button after each pass and the screw-down moves up or down, as the case may be, and stops with the rolls in the proper position for the next pass. The stopping points of the screw-down can be pre-set so as to automatically give the proper opening of the rolls for each successive pass. Such an equipment has distinct advantages as:

1. Uniformity of product by continued repetition of a definite schedule of rolling, irrespective of the change in operators on the different shifts. There is naturally a variation in the skill of different operators, and there are times when it is necessary to break in "green" operators; the Automatic Pre-set Control makes the product independent of these elements.

2. Improved quality of product by taking the proper drafts. This is particularly true in the case of Blooming and other Roughing Mills as the final quality of the steel is largely determined by the initial rolling, particularly in the first several passes.

When the control equipment is set up in accordance with a definite schedule of passes and drafts, as specified by the mill superintendent or by the metallurgist, it not only eliminates human errors in the drafts but also prevents an operator from deliberately taking larger than the specified drafts in order to increase the tonnage.

3. Increased production by eliminating the loss of time due to "inching" in order to set the rolls properly.

4. The ability to roll different sizes of ingots, or to roll them to different sizes of blooms or slabs, without loss of time and with assurance of uniform quality of product.

This applies particularly to Blooming Mills. The ingots are not always of the same size,—there may be several sizes and since they are taken to the Blooming Mill according to the proper temperature reached in the Soaking Pits, it follows that there is no definite sequence, as to size, in the succession of ingots as they reach the mill.

D. C. WRIGHT

Also, a Blooming Mill may be serving two or more finishing mills requiring different sizes of blooms or slabs, and if these finishing mills are running at the same time the Blooming mill will have to turn out different sizes of product according to the demand.

The different sizes of material coming to, or leaving the mill, require different drafts and may require a different number of passes, and it is not hard to visualize what it means for an operator to have to remember the different changes required in the rolling or even to follow several written schedules.

5. Increased efficiency of the operators because the automatic pre-set control enables them to follow a specified schedule of rolling with much less mental strain, and also less physical exertion by eliminating the many "inching" movements involved in a manually controlled equipment.

In order to be successful, an Automatic Pre-Set Control on screw-downs cannot be rigidly fixed as regards adjustments—it must be flexible in adjustment of draft, in the number of passes, and should allow proper control for any emergencies which might arise; for instance:

1. It may be necessary to change one or more drafts slightly after checking a rolled piece with the calculated specifications.
2. It may be necessary to change the number of passes for the same reason.
3. Even after everything is going smoothly it may be necessary to make changes to compensate for the heating of the rolls in some types of finishing mills; this probably does not apply to blooming and other roughing mills.
4. The main rolls have to be turned down, or re-finished, when they have been worn to a certain degree. The whole set-up must be changed as a unit to compensate for this.
5. The operator should be able, instantly, to assume control by manual means in case of a cobble, or in case of some other unavoidable delay, which in all likelihood requires that the piece be rolled at reduced drafts and at an increased number of passes. In such cases, it is not practical to change the automatic set-up for the single piece; but, when the emergency has been disposed of, it must be possible to reinstate the automatic system where it was interrupted or at any other point in the set-up in case one or more of the regular passes have been manually operated.

With these thoughts in mind, there has been developed and exhibited at this Convention, a new Automatic Pre-Set Screw-down Controller of the following specifications:

1. Maximum roll travel—53-15/16".
2. Minimum movement—1/16".
3. Number of automatic passes—11 (This was chosen as covering the maximum number of passes where steel might be damaged in the first rolling operations. Any number of passes up to 25 or 50 can be made automatic with very little additional apparatus).
4. Ability to select instantly any one of four different rolling schedules required for different sizes of blooms or billets. (This number can easily be decreased or increased by slight decreases or increases in apparatus).
5. Ability to interrrupt or reinstate the automatic operations at the will of the operator.

The control consists of ten major units which are shown and indicated in Fig. 1 and Fig. 2, as follows:

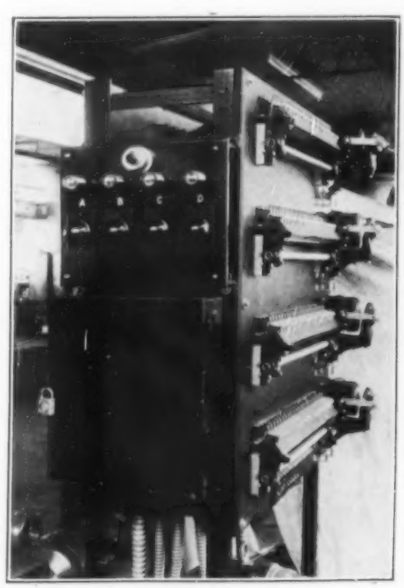

FIG. 2

1. A Full Magnetic Reversing Plugging Controller, with the addition of two points of armature shunt and dynamic braking.

2. A Control Relay Panel wich includes the control for a fractional horse power set-up motor and all the relays required for the automatic preset features; it also includes the control for two Selsyn, or synchronous-tie, motors for synchronizing the control equipment with the screw-down motor.

3. An Automatic Differential Gear Unit, which is driven by the screw-down motor through

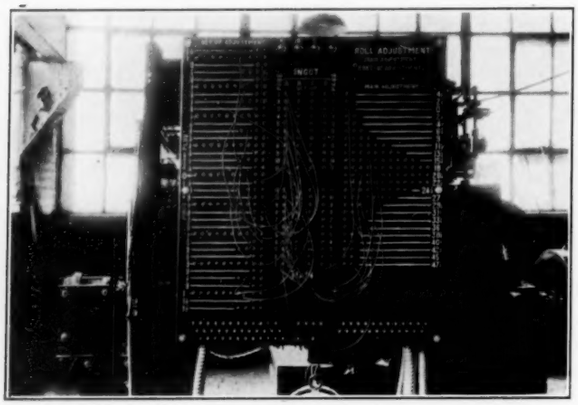

FIG. 3

the two Selsyns. This unit contains the following essential parts which are mounted on a structural steel frame forming a single unit:

Rm—A main rheostat (cover removed) which functions in the pre-setting when large movements are to be made.

Rv—A Vernier Rheostat (cover in place) which functions when small movements are to be made and also in the case of a large movement which is slightly greater or less than a unit movement provided by the main rheostat.

C—Automatic Cut-out which controls the final stopping of the screw-down motor.

Se—A set-up motor.

W—Worm gear reduction through which the set-up motor drives the cut-out and both rheostats.

Syr—Selsyn Receiver Motor.

D—Differential Gear through which the Selsyn Receiver Motor drives the cut-out and the main rheostat.

4. A Plug-in Panel including a pair of adjustable plugs for each pass and numerous receptacles whereby the desired stopping point for each pass can be selected by putting the plugs in the proper receptacles. See Fig. 3.

5. A Selector Relay Panel consisting of four multipole relays; this panel mounted back-to-back with the plug-in panel (4) as shown in Fig. 1, a front view being shown in Fig. 2.

6. One Operator's Push Button Station, including four push buttons; one for overload and no-voltage reset; one for regular operation for each pass; and two for reinstating the automatic control at any pass. This panel also includes indicator lamps to show the pass at which the cut-out stands ready for the next operation. See Fig. 4.

7. A Reversing Master Switch for manual operation of the screw-down. This is practically a standard master having three running points in each direction, the first point with shunted armature; it also has interlock contacts which make it necessary for it to be in the "off" position in order to operate from the operator's push button station.

8. A Selector Push Button Panel for controlling the selector relay panel (5), shown in Fig. 2.

9. A Synchronous-tie Motor which is geared to the screw-down motor.

10. A Series Wound Brake for the screw-down motor.

Installation: The only piece of apparatus mounted on the mill is the synchronous-tie motor, which requires only five wires run from the control room to the mill. This motor is fully enclosed to withstand the dirt and abuse encountered at this point. The motor must be properly geared to the screw or the screw-down motor to drive the cut-out at the proper ratio with the mill.

The Automatic Differential Gear Unit, the Plug-in Panel, and the Selector Relay Panel are all mounted on one common base with inter-wiring done at the factory. This panel with the Control Relay Panel and Full Magnetic Controller, can be mounted in the control room remote from the mill and operator's pulpit.

The Reversing Master Switch, the Operator's Push Button Station, and the Selector Push Button Panel are mounted in the operator's pulpit. The first two within easy reach of the operator as they are his operating tools; the third, within reach, although it is only operated when changing to a different size of bloom or billet.

Operation: The Plug-in Panel is first set in accordance with the roll schedules specified by the mill superintendent or the metallurgist. This is not a complicated procedure and can easily be accomplished in from 2 to 2½ minutes for each schedule. Each of the four rows of plugs with flexible cords

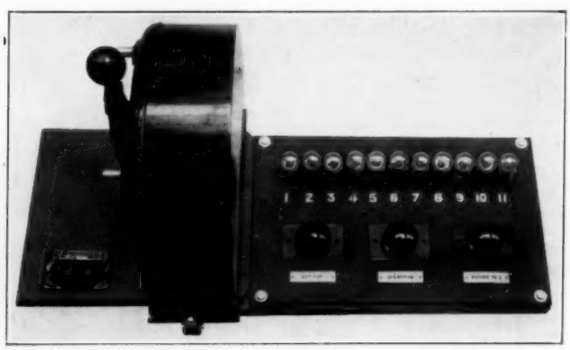

FIG. 4

represent different schedules, namely, A, B, C and D. Each row has 22 cords, divided, 11 for main adjustments and 11 for set-up adjustments; that is, two cords for each pass. The top 11 cords are for set-up adjustment and the 11 at the bottom are for main adjustment. The receptacles on the right are for the main adjustments in increments of 2¼". Those

at the left are for set-up adjustments in increments of 1/16". The desired roll separation is the algebraic sum of the two adjustments. Zero quantity on the set-up side is at the center. Rows of receptacles below this represent negative or minus sixtenths and rows above zero represent positive or plus sixteenths. Assume that it is desired to set # 3 pass of Schedule A for 28-5/16", then #3A main plug, would be put in receptacle 29¼ and #3A set-up plug in minus 15/16. Should it be desired to change this setting to add a sixteenth to the roll separation, the set-up plug is simply raised to the next row of receptacles above. By this plug-in scheme, any pass can be set at any 1/16" position between 0" and 53-15/16"; or any one of 864 possible stopping points can be chosen.

After any of the schedules have been "plugged in," the device is ready for operation. The operator must first close the snap switch and then by pressing

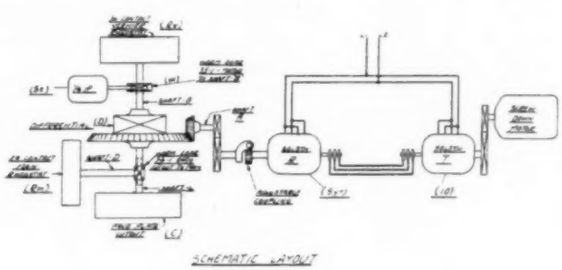

FIG. 5

the proper button on the Selector Panel, the circuits for the desired schedule are connected in. Pressing the right-hand button on his Operating Station, causes the cut-out to adjust itself ready for #1 Pass, as shown by #1 indicator light. Pressing the operating button causes the screw-down motor to start, accelerate and stop at No. 1 position. Just after the motor stops, the cut-out automatically adjusts itself ready for No. 2 Pass. No. 1 pilot light goes out and No. 2 lights up, showing the cut-out is ready. Pressing the operating button again causes the motor to go to No. 2 position. The operator simply presses the operating button repeatedly for each pass. After the last pass the cut-out automatically adjusts itself for the first pass, and everything is ready for the operator to start to repeat his cycle for the next ingot. Should this ingot be rolled on a different schedule, for instance B instead of A, pressing B button on the Selector Panel connects B schedule in circuit instead of A, so the operator is instantly ready for the new size of ingot.

In case a cobble occurs or in case any other trouble happens, the operator can instantly assume manual control by means of his reversing master switch adjacent to the operating station. After this trouble has been corrected either by finishing the rolling of this bloom by manual means, or after rolling a few passes, he can return to automatic control by returning his manual master to the off position. This connects the automatic control in at the place where it was interrupted and will probably necessitate re-setting of the cut-out for starting operation on the proper pass. If a new bloom is ready, pressing of the right-hand set-up button instantly sets the cut-out ready for No. 1 Pass. If the cobble bloom was not finished, pressing the left-hand set-up button brings the cut-out in position for the desired pass, as shown by the indicator lights.

Accuracy: The push button operation under automatic control is extremely simple and should not be at all fatiguing, either physically or mentally, to the operator. The accuracy under automatic control is in excess of that obtained under manual control, even by the most experienced operator. With the range of travel shown in the specifications, the accuracy of stopping is less than plus or minus 1/32". If the control was used on a smaller mill with total roll movement of approximately 27", then the minimum movement could be made 1/32", with accuracy of less than ±1/64".

Explanation of Control: The mechanical features of the Automatic Differential Gear Unit are shown on Fig. 5. This shows the Selsyn Transmitter Motor (10) geared to the screw-down motor and the Selsyn Receiver Motor (Syr) geared to the driving bevel pinion of the differential gear. Two shafts, B and C, extend out of the differential gear, corresponding to the two axle shafts of an automobile. On the end of the shaft B is the 36-contact Vernier Rheostat (Rv). On this shaft B is also mounted the worm gear reducer (W) which is driven by the set-up motor (Se) at a ratio of 35-1, that is, the motor makes 35 revolutions for one revolution of shaft B; however, the exact gear reduction is immaterial.

On the end of shaft C is the faceplate cut-out (C) with rings for the directional contactors of the screw-down controller and rings for the first and second armature shunt points. This cut-out is used for the actual slow-down and stopping of the screw-down motor and always stops with its arm at the top position.

On shaft C is another worm gear which drives shaft D in the ratio of 24 to 1, that is, shaft C makes 24 revolutions for one revolution of shaft D. At the end of shaft D is mounted the 24-contact main rheostat (Rm).

When the screw-down motor rotates, it operates the driving pinion and ring gear of the differential, but since shaft B cannot revolve because of the locking worm gear between it and the set-up motor, then only shafts C and D are rotated. This is similar to the operation obtained in case one rear wheel of an automobile is jacked up and the engine turned over.

In order to set up for small movements, it is necessary to change the positions of the contact arms on the cut-out (C) and the vernier rheostat (Rv) with respect to the position of the rolls; to do this when the screw-down motor is idle, the set-up motor (Se) is operated. This drives shafts B and C at the same speed but in opposite directions and drives shaft D at 1/24th the speed of shaft C. The ring gear and pinion remain idle during this operation. (This is similar to jacking up both rear wheels of an automobile and turning one wheel, with the engine clutched in, but idle).

The gear reduction between the screw-down motor and the differential drive has been made such, that, from one contact to another on the 24-contact main rheostat represents 2¼" travel of the rolls, also, this corresponds to one revolution of cut-out C since this rotates 24 times as fast as the main rheostat. One thirty-sixth of a revolution of C, or 10

degrees, would therefore represent 1/16" roll movement.

Since the Vernier Rheostat (Rv) has 36 contacts, the movement from one contact to another is equal to 10 degrees or corresponds to 1/16" roll movement. The Set-up Motor (Se) can be made to operate the Vernier Rheostat to any one of the 36 contacts and stop there.

Thus, while the screw-down motor is idle, the set-up motor can be made to drive the cut-out arm (C) through any increment of 10 degrees that it is desired. The set-up motor is used when it is desired to make any movement that is not a multiple of 2¼". For instance, if it is desired to make a ⅛" movement of the rolls, the set-up motor is first operated to cause the cut-out arm to move backwards 20 degrees; and the screw-down motor is then started and drives the cut-out arm forward 20 degrees, at which point the motor is stopped, giving a ⅛" movement of the rolls. Either an upward or downward movement can be chosen. This is all determined by the position of the plugs in the Plug-in Panel for the set-up adjustment.

All movements up to 1⅛", and the last 1⅛" of all movements above that amount, are always under control of the cut-out. This corresponds to 180 degrees movement of the arm, and as the radius of the control rings is approximately 6", gives practically a 19" finger movement for 1⅛" roll movement, hence the accuracy in stopping at the desired point.

For all movements above 1⅛", the main rheostat has control of the directional contactors up to the last 1⅛" of travel. The position of the plugs in the main adjustment receptacles determine just how many increments of 2¼" the travel shall be and also determine whether the motion is up or down.

The operation of the set-up motor, which drives the vernier rheostat and the cut-out arm for proper set up of the cut-out, is automatic. It starts operation, whenever necessary, immediately after the screw-down motor stops, so as to put the cut-out in proper position for the next pass while the steel is being run through the mill on the previous pass. Thus, no loss of time occurs for the set-up operations of the cut-out.

A special slip coupling is interposed between the receiving synchronous tie-in motor and the differential, by means of which it is easily possible to change the position of the cut-out with respect to the rolls. This is necessary when first setting up so as to synchronize the stopping position of the cut-out with the rolls. Also it gives an easy means for readjustment after the rolls have been turned down, or bearings have been changed. For instance, if the roll was turned down 2" in diameter, all stopping positions as determined by the previous plug positions would be 1" "off." The worm screw of the slip coupling can be turned the proper number of turns to resynchronize the stopping positions with the gauge.

All bearings in the Differential Gear Unit are high-grade ball or roller bearings, and all gears and bearings run in tight cases filled with oil.

The Synchronous tie-in motors could be omitted and the Differential Gear Unit geared directly to the mill. This, however, would require a considerable number of wires run from the cut-out to the control room and may not be desirable.

Application: For blooming mill applications, such as have been described, it is advisable that the plug-in panel be kept away from the operator so that he cannot change the drafts to suit his own ideas. The mill superintendent, or some one in authority, should be responsible for the plugging-in operation. If it is desired to make any changes on one schedule while another is being rolled, this can be done without danger, as the plugs in any "dead" schedule can be removed and replaced without interrupting the "live" or operating schedule. A tell-tale instrument can be mounted in the superintendent's office to indicate each time each schedule is used or each time the operator uses manual instead of automatic control.

The automatic control as described can be used for other than blooming mill screw-downs. In these days of short runs and small orders, it is necessary to frequently change the settings of roll position on continuous mills. A screw-down control of this type on each mill housing, will give ability to instantly change all of the roll positions to suit a new size of material with all necessary accuracy.

On plate or sheet mills where the maximum movement of the rolls may be only ¾", the control can be applied to give minimum movement of .001". For such an installation, it might be desirable to replace the plug-in panel with a simple system of dial switches mounted near the operator, so that he can easily change the schedule to compensate for expansion due to heating of the rolls or housings. In this case, the Selector Relay Panel and the Selector Push Button Panel can be omitted as only one definite schedule is rolled.

It is easily possible to increase the number of steps of the main rheostat from 24 to 32. With this number the following maximum and minimum movements are possible.

79-15/16"	total	movement	1/16"	minimum	movement
39-31/32"	"	"	1/32"	"	"
1.151"	"	"	.001"	"	"
95'-11"	"	"	1"	"	"
1151'	"	"	1'	"	"
360 deg.	"	"	1/3 deg.	"	"

Designs have been made for adding a second main rheostat geared to the first main at proper ratio. With this arrangement and with 32 contacts on the set-up rheostat and 24 contacts on each main rheostat, the cut-out could be geared so that each contact on the first main would control 4 ft. travel; each contact on the second main would cover 2" travel and each contact on the set-up would control 1/16" travel. This would then give control over 95' —11-15/16" travel at 1/16" increments or it would be possible to select any one of 18,532 stopping points, 1/16" apart.

Such an arrangement would give ideal control for a shear gauge stop, where it is necessary to change the setting frequently over widely varying distances. It would give accurate stopping without the necessity of measuring and inching or plugging to get the desired stopping point. The plug-in panel would be omitted and three small rheostats or dial switches would be used to select any proper stopping point.

It is thus seen that the type of cut-out and control described, lends itself for any application where it is desired to cause the motor to revolve for almost any number of revolutions and then stop.

Discussion

Discussion Presented by

J. Farrington, Electrical Superintendent, Wheeling Steel Corp., Steubenville, Ohio.
D. C. Wright, Chief Engineer, Electric Controller & Mfg. Co., Cleveland, Ohio.
C. A. Kral, Supt. of Blooming Mill, Bar and Hot Strip Mills, Wheeling Steel Corp., Steubenville, Ohio.
A. J. Standing, Electrical Superintendent, Bethlehem Steel Company, Bethlehem, Pa.
G. R. Carroll, Electrical Superintendent, Jones & Laughlin Steel Corp., Aliquippa, Pa.
J. L. Edwards, Supt. Rolling and Finishing Mills, Republic Steel Corp., Chicago, Ill.
A. M. McCutcheon, Vice President, Reliance Electric & Engineering Co., Cleveland, Ohio.
F. L. Estep, Vice President, Perin Engineering Co., Inc., New York, N. Y.
A. F. Kenyon, General Engineer, Westinghouse Electric & Mfg. Company,, East Pittsburgh, Pa.

J. Farrington: There is one question I would like to ask. In case an ingot comes up cold and the operation is set for a certain draft, how does the control automatically take care of that difference in temperature?

D. C. Wright: The automatic screwdown control as described does not automatically take care of temperature variations of the ingot. Proper rolling of the cold ingot has to be done by manual means and is left up entirely to the operator's judgment. If he judges that the ingot is too cold to roll on the specified schedule, then he has to reduce the drafts and increase the number of passes, as he would ordinarily do, without the automatic controller.

C. A. Kral: I'm just wondering as to that set-up, who sets the draft—who plugs in? Is that taken care of by the roller?

D. C. Wright: The rolling schedule has to be determined, presumably, by the metallurgist or rolling mill engineer, and I should think that some one in authority rather than the screwdown operator, should do the plug-in operation of the schedule panel. This, of course, can be done by the boss roller or by the mill superintendent, and if the superintendent wants the schedule fixed a certain way, he ought to plug it in and say: "There, leave it alone," or else the screwdown operator may make changes to suit his own ideas. It is a simple matter to plug in and only requires approximately two minutes for any schedule.

A. J. Standing: I don't think the matter of who plugs in has anything to do with the question. The rolling schedule is set up by the mill superintendent and a written set-up is given to the roller or the electrician—or anyone else can do the plugging-in as far as that is concerned. But I think the vital thing the mill people here ought to discuss is what is going to be the result of this or any similar system. Is it going to mean an improved product? Is it going to eliminate a possible operator—going to make for lower costs? Just what do you think that you can gain from the mill standpoint that is going to justify this equipment. That's what I want to hear discussed.

D. C. Wright: I would judge that the operating men assembled here would be better able to discuss costs than I am. However, I believe that everyone will agree with me in stating that a great deal of damage can be done to the steel if improper drafts are made, particularly on the first few reductions.

One mill superintendent has informed me that if his mill could be arranged to control the first nine passes of all of his schedules so that they would be rolled in accordance with the specifications, practically all of the damage to the steel could be eliminated, and the control equipment would soon pay for itself in savings reflected by chipping costs.

G. R. Carroll: I think that is the trend the discussion should take. I would like to see the real justification of this scheme. It is very well worked out, and Mr. Wright mentioned in the first part of his paper just what the returns would be from an investment of this kind. This subject has been discussed considerably by some of the steel men, that is, the operating superintendents in the blooming mills, but I realize it is very hard for them to come right out and make a flat statement on it. But I feel that there is a demand for that kind of equipment—if not in a blooming mill, in other applications.

J. L. Edwards: What would be the approximate cost of a machine of this kind for a 40" Blooming mill? You would have to know the approximate cost in order to set it up against the saving in labor, as this would be the first question asked, as to whether it would be possible to eliminate the Screw Operator from the pulpit. I believe the automatic screw, as shown by your demonstration, to be very good and think it can be worked out for a Blooming mill to a good advantage. On jobbing Blooming mills you usually have a number of different grades of steel to be rolled as well as many sizes which must be rolled intermittently, therefore it would be necessary to have a sufficient number of set-ups and combinations to take care of the various grades and sizes to be rolled.

From my experience in Blooming mills, I find that the uneven heating temperature, (and that is ingots which are unevenly heated and not soaked), are the biggest factor the Screwman has to contend with. In other words, you may be able to pull two inch drafts if your steel is properly soaked without damaging the steel, then on the other hand you may start to roll an ingot which is not properly heated or soaked on which you cannot pull an inch and one half draft without stalling the drive or causing a break in the machinery. Unless you have modern heating equipment whereby you can maintain even temperatures, it will be necessary that the automatic screw can be changed quickly to take care of those ingots which are not properly heated. This I understand can be done by using the manual control.

I believe this automatic screw down can be worked out to the best advantage on Blooming mills which are feeding continuous mills, due to the fact that there are not so many sizes or combinations in rolling to be taken into consideration, as there are on jobbing mills.

It is very important on Blooming mills feeding continuous mills that the size of the bloom be kept as close as possible to the size ordered by the continuous mill Roller, otherwise the continuous mill will experience trouble in entering or biting and in many cases the variation in the bloom size delivered to the continuous mill results in cobbles or buckles. This question has always been a bone of contention between the Blooming mill Screw Operator and the continuous mill Roller. Therefore, I believe the automatic control would be the means of correcting this condition.

G. R. Carroll: Is there anybody here who would be willing to state just what the effect would be on the quality of the steel after the setting-up of such a definite program, presupposing that you could regulate a constant temperature coming out of the pits?

A. J. Standing: I want to learn something about this. Suppose we assume we have a jobbing blooming mill. This bloomer could have three schedules, as I understand it. You could run on Schedule A and produce 8 by 8 blooms with an accuracy of a sixteenth of an inch; you could set a Schedule B and produce 5 by 5 blooms automatically; then you could continue on to Schedule C and produce, say, 3 by 3 blooms. Is there enough benefit in accuracy within a sixteenth or less on blooms serving various mills to justify this equipment? Assuming that it is possible to replace a man if your modern motor driven bloomer is run by two men—I understand that's been tried with some degree of success—but assuming you have two men operating and you can eliminate one, are you getting enough return for your investment to justify the installation of the equipment as described by Mr. Wright?

J. L. Edwards: In regards to the quality and the cost of chipping, I am of the opinion that the quality can be improved and the chipping cost reduced if we were to have ideal heating conditions and if we were to take light drafts and turn the ingot oftener on the first several passes and continue with the uniformly heavier drafts as the area of the section is reduced. At the present time, I believe that most Blooming mills will produce more tonnage on the night turns than they do on the day turns. This, I believe, is due to the night crews cheating, by this I mean the average Blooming mill Roller or Screwman will pull excessively heavy drafts which usually result in poor quality and high chipping cost, also high maintenance cost. I believe the automatic screw down would be a big factor in eliminating this condition providing it was connected up with a recording chart, then it would be possible to check. We now find that it is common practice for the average Blooming mill Roller or Screwman to change the drafts contrary to the orders given by the Superintendent, as they are apparently only interested in the amount of tonnage which they can get through the mill, regardless of the excessive amount spent for chipping after rolling.

This automatic screw down mechanism should be made to operate as rapidly as possible, so that rolls can be adjusted to the proper position in order to speed up the rolling without damaging the machinery.

On our present Blooming mills with manual control screw downs it is common practice for the Screwman to ride the back end of the piece, (by this I mean he will start the screw down in motion before the back end is entirely out of the mill). This usually results in rapidly worn out screws and sleeves and in many cases the burning up of the screw down motor armatures. The advantage of this automatic control is that the screw control is set for the next pass while the piece is still passing through the rolls, but is only brought into motion on the main screw down as quickly as the piece is out of the roll.

D. C. Wright: The screw-down control as described allows the set-up motor to immediately change the set-up for the next pass, after the screw-down motor has stopped, so that, the operator can push the operating button and again start the screw-down motor as soon as the ingot has passed through the rolls. No means are provided to prevent the operator from starting the screw-down motor before the piece has passed the rolls. However, a flag switch could be added to prevent operation of the screw-down motor in the down direction until the ingot has passed the rolls. This feature, of course, should be connected in on the down direction only, leaving it possible for the operator to bring the rolls away from the piece at any time in case of emergency.

J. Farrington: I'd like to ask Mr. Wright if he thinks it would be possible to add some kind of a load relay so that, if the rolls were set for a certain draft and the steel was cold, that the relay would automatically raise the rolls and allow you to take the desired draft, not in one pass but in two passes for that cold steel? And in order to save the expense, could you make that applicable to, say, the last two or three passes to get your definite finished dimensions?

D. C. Wright: This is quite a problem to be put up for a quick answer, but I would say that the automatic controller could be arranged so as to interpret the temperature of the ingot by providing necessary thermo relays which could operate on other relays to select a proper rolling schedule, dependent upon temperature of the ingot. However, this would all have to be worked out after considerable study and in all likelihood would require considerably more apparatus than shown.

A. M. McCutcheon: I have not seen this in operation in the mill. I have seen it in operation in the plant at the invitation of the EC&M Co., and it's one of the best worked out pieces of equipment that it has been my pleasure to see. I can't give the information that the gentleman from Bethlehem was asking about as to how much value it's going to have in the mill; but I certainly will testify that, from an engineer's viewpoint, it's a beautifully worked out piece of equipment and does exceedingly well what it has been planned to do.

F. L. Estep: I would be interested in having

somebody tell what this automatic screwdown will do from a practical operating standpoint on a 3-high mill operating as a rougher on sheet bar with three-quarters of an inch maximum opening.

D. C. Wright: If ¾" would represent the full roll movement, adjustments of .001" can be obtained by the screwdown. In addition, a jog button could be added to get even a smaller movement on top of the .001" movement, if this was necessary. Also, automatic means could be used to turn the adjustable coupling between the Selsyn drive and the differential, so that all settings could be changed a very small fraction of .001" to compensate the expansion due to heating of the rolls or roll housings.

F. L. Estep: But with your rolls running hot, or if they are wet mills, you're getting a certain change in their size. You have to have some means of handling your set-up accordingly.

A. F. Kenyon: In reply to Mr. Estep's inquiry, I might mention that our company has built recently several automatic screw-down equipments which are now operating on three-high sheet mills. The form of equipment is somewhat different from that described by Mr. Wright.

In rolling sheet it is necessary to be able to change schedules quickly and to be able to make extra-schedule passes if desired. Therefore an automatic screw-down for sheet mill service must be a combination pre-set and follow-up device. Roll settings are made by means of lever handles on a limit switch located on a pedestal adjacent to the mill stand. The entire equipment is compact and simple and quickly adjusted to varying sheet mill schedules.

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Welded Steel Construction

By LLOYD JONES,
Vice President, Continental Roll & Steel Foundry Company, Pittsburgh, Pa.

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Presented before the Welding Engineering Division of the A. I. & S. E. E. at the Twenty-Ninth Convention in Pittsburgh, October 19, 1933.

Welded construction is here—its good, lets like it, whether it effects our particular industry or not. The subject given me to discuss, "Advantages to be secured through Welding in Mill Building" covers a lot of territory. When you consider the various products of the industry, for example: Billets, Rails, Plates, Wire, Pipe, Sheets, Tin Plate, Structural Shapes, Bars, Strips, Rods, etc. You can begin to perceive the many varied kinds of machinery necessary to turn out the finished products. The speaker knows of no branch of the Machinery Industry, that calls for the production of such vast diversification of machinery as is required of the "Mill Builder."

Welding is going to play an important part in these varied lines of Mill Machinery, as in order to increase the demand for "Rolled Steel Products" most of our customers today specify in their inquiries "Welded Steel Construction."

It is to our ultimate interest, that the demand for rolled products be maintained at a good rate, as this will increase the demand for our products—namely, rolls and the reproduction of worn-out Mill Machinery.

Welded Steel Construction when "properly designed" is **usually** economical especially **if only one or two pieces are required of a certain part.** Now, the entire matter hinges on the term "properly designed." The mere substitution of one kind of metal for another is not necessarily Good Engineering. The term "Welded Steel Construction" does not imply the exclusive use of rolled steel products. Steel castings have their proper place in our economic structure and steel forgings also have their uses. As a Mill Builder, the speaker interprets the phrase, "Welded Steel Construction," as that combination of rolled steel products and steel castings and steel forgings, so planned that when welded together they produce the best economical and practical machine construction.

The welded combination of rolled steel and steel castings, has lately come into such prominence that it appears logical for the Mill Builder to engage in the welded fabricating business, connected with their Steel Foundries. This is an economic advance, as they already possess most of the facilities—namely, buildings, annealing furnaces, cranes, welding equipment, flame cutting equipment, lacking only shears and bending or forming machines. Furthermore, any scrap produced can be utilized in their furnaces for Steel Castings.

In keeping in step with the spirit of the times, it looks like good business for the "Mill Builder" to follow along the lines mentioned, as it will make a more balanced proposition, saving investments which might otherwise have to be written off as a loss. Another important reason is that economy and experience will be an important factor in determining the percentage of steel castings used in welded construction. Recent developments have shown that the grain structure of the material has much to do with impact resisting properties. Therefore, when parts of machines are subject to blows or sudden stresses it may be better engineering to use for that portion of the apparatus a heat treated special steel

casting possessing high dynamic properties. It is not always possible to heat treat a complete machine after it is welded, and while the rolled steel may possess high dynamic properties, the weld and adjacent portions may not. This is especially true when you consider that to bring out these high dynamic properties in steels, quenching is frequently a part of the heat-treatment. Those engineers who are engaged in the use or manufacture of sheets and tin plate with deep drawing or stamping properties will readily appreciate the importance of proper grain structure, and the difficulties in securing same. Therefore, the metallurgist and chemist should cooperate with the engineer or designer in welded construction, as well as assisting in the manufacture of rolls and special analysis steel castings all of which are a product of the "Mill Builder."

Let us for a few moments look into what the speaker termed "Properly Designed" construction. Many preconceived ideas, will undergo radical changes and our designers will be called upon to exercise considerable ingenuity and study. The rolled products at hand are plates and various shapes, such as angles, channels, beams, etc. Most of these rolled shapes were especially designed for the construction of bridges, buildings, etc., for which they are admirably fitted. When it comes to using them in machine design, they are not so adaptable and the speaker believes certain sections should be modified, or new ones developed. At least one concern is having special sections rolled. They are fortunate enough to require a sufficient tonnage to warrant the expenditure necessary in shape-rolls and guides. Other manufacturers cannot afford this of their own requirements. When bulked together, all of these manufacturers would use a considerable tonnage. Therefore, it might be pertinent at this time, for some Engineering Society to have a Committee study this problem, in conjunction with the producers of Rolled Steel Products, thereby helping the designer, standardizing the required shapes and avoid costly mistakes.

At the present we are dependent largely on plates which are sheared, formed and welded together in conjunction with steel castings, cut slabs or forgings. In the forming or shaping of these plates, combining the judicious use of steel castings, lies the possibilities of economical versus extravagant and pleasing versus awkward designs. A bend in a plate, if performed cheaply is better than a weld, and generally more pleasing to the eye.

The designer, therefore, should familiarize himself with the bending and forming facilities now available. Obviously, where few parts are to be formed, we cannot adapt the costly die and press method, used in the manufacture of automobiles, refrigerators, etc. You are limited, therefore, to bending rolls and other machines, which can be cheaply rigged for forming. Such a machine is available for bending plates 3/8" thick and heavier, which equipped with a few simple and standard dies, will economically produce an unbelievable number of various forms and shapes.

Let me again repeat, that in my judgment, the less welds required, the cheaper will be the construction and the better the product. Designers should also keep this fact in mind. With this new type of construction, the latest ideas in bearings, lubrication, maintenance, safety and general utility, should be incorporated into the designs, as you are no longer handicapped with old patterns and casting limitations.

ITEMS OF INTEREST

PERSONNEL CHANGES

W. H. Warren has been appointed General Manager of the Steubenville Plant of the Wheeling Steel Corporation, and took over the duties of the position on December 18. He succeeds J. E. Daily who has been appointed General Superintendent of the Chicago Plant of the Youngstown Sheet & Tube Company.

W. H. WARREN

Mr. Warren was formerly associated with the Babcock & Wilcox Company at Beaver Falls, Pa., where he was engaged in consulting work. Previously he was Vice President in charge of operations for the Lukens Steel Company at Coatesville, Pa., and he held the same position with the Trumbull Steel Company at Warren, Ohio. He was General Manager of the Brier Hill Steel Company at Youngstown, Ohio; also previously Superintendent of Mills at the Gary Plant of the Illinois Steel Company.

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Eugene W. Pargny, President, American Sheet & Tin Plate Co., Pittsburgh, since 1909, who has been on leave of absence since January 1, has requested that he be relieved of his duties January 1, 1934, retiring under the pension plan of the United States Steel Corporation. Charles W. Bennett, Vice President, who for the past year has served as Acting President, will succeed him.

(Continued on page 373)

ANNOUNCEMENT

TO THE

Membership and Manufacturers of Steel Mill Equipment

At the last Board of Directors' Meeting of the A. I. & S. E. E., held December 16, 1933 it was decided that the 1934

Convention and Iron and Steel Exposition

will be held in Cleveland, Ohio at the Cleveland Public Auditorium, September 18, 19, 20, 1934.

Floor Plans will be mailed in January 1934.

General View of 1931 Iron and Steel Exposition in Cleveland Public Auditorium.

To the Advertisers in the Iron and Steel Engineer
To the Exhibitors in the Iron and Steel Exposition

The President, the Board of Directors, the officers of the District Sections, the National Committeemen, the Chairmen of the Mechanical, Lubrication, Electrical, Combustion and Safety Divisions desire to express to you their sincerest appreciation for your 1933 advertising co-operation.

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NATIONAL CARBON COMPANY, INC.
THE NEW DEPARTURE MFG. COMPANY.
THE NICHOLS-LINTERN COMPANY.
NORMA-HOFFMANN BEARINGS CORPN.
THE OHIO ELECTRIC MFG. CO.
PENNSYLVANIA TRANSFORMER CO.
POOLE FOUNDRY & MACHINE CO.
RAILWAY & POWER ENGINEERING CORP., LTD.
REITZ SALES CO.
RELIANCE ELECTRIC & ENGINEERING CO.
ROCKBESTOS PRODUCTS CORPORATION.
ROLLWAY BEARING COMPANY, INC.
ROLLER BEARING COMPANY OF AMERICA.
JOSEPH T. RYERSON & SON, INC.
SCHLOEMANN ENGINEERING COMPANY.
SKF INDUSTRIES, INC.
STIMPLE & WARD CO., INC.
THE TEXAS COMPANY.
THE THOMPSON ELECTRIC COMPANY.
THE TIMKEN ROLLER BEARING COMPANY.
THE TOOL STEEL GEAR & PINION CO.
THE TRUMBULL ELECTRIC MFG. CO.
UNION CARBIDE & CARBON CORP.
UNITED ENGINEERING & FOUNDRY COMPANY.
R. E. UPTEGRAFF MFG. CO.
THE WEAN ENGINEERING COMPANY.
THE WELLMAN ENGINEERING COMPANY.
WEST PENN POWER COMPANY.
WESTINGHOUSE ELECTRIC & MFG. CO.

1933 EXHIBITORS IN THE IRON AND STEEL EXPOSITION

ALLIANCE MACHINE CO.
ALLIS-CHALMERS MFG. CO.
BACHARACH INDUSTRIAL INSTRUMENT CO.
BAILEY METER CO.
BARTLETT-HAYWARD CO.
BENJAMIN ELECTRIC MFG. CO.
BULLDOG ELECTRIC PRODUCTS CO.
BURNDY ENGINEERING CO.
CLARK CONTROLLER CO.
COLTS PATENT FIRE ARMS MFG. CO.
CROUSE-HINDS CO.
CUTLER-HAMMER, INC.
DUQUESNE LIGHT CO.
EDISON STORAGE BATTERY CO.
ELECTRIC CONTROLLER & MFG. CO.
FAFNIR BEARING CO.
FARVAL CORPORATION.
FOXBORO COMPANY.
GENERAL ELECTRIC CO.
GENERAL ELECTRIC SUPPLY CORP.
GORDON & CO., R. M.
GRAYBAR ELECTRIC CO., INC.
G & W ELECTRIC SPECIALTY CO.
GREAT WESTERN FUSE CO.
HABIRSHAW CABLE & WIRE CORP.
HOMESTEAD VALVE & MFG. CO.
HYATT ROLLER BEARING CO.
I-T-E CIRCUIT BREAKER COMPANY.
JOURNAL LUBRICATOR CO.
KEYSTONE INSULATOR CO.
LAPP INSULATOR CO., INC.
LEEDS & NORTHRUP CO.
MORGAN ENGINEERING CO.
MULLER & CO., HENRY N.
NATIONAL ARMATURE & ELECTRICAL WKS.
NATIONAL CARBON CO.
OHIO CARBON CO.
OTIS ELEVATOR CO.
PENNSYLVANIA LUBRICATING CO.
PITTSBURGH REFLECTOR CO.
POOLE FOUNDRY & MACHINE CO.
RELIANCE ELECTRIC & ENGR. CO.
ROLLER-SMITH CO.
ROLLWAY BEARING CO., INC.
SCHWEITZER & CONRAD, INC.
SKF INDUSTRIES, INC.
TIMKEN ROLLER BEARING CO.
TOOL STEEL GEAR & PINION CO.
TRUMBULL ELECTRIC MFG. CO.
UNITED AMERICAN BOSCH CORP.
UPTEGRAFF MFG. CO., R. E.
EDWIN L. WIEGAND CO.
WESTINGHOUSE ELECTRIC & MFG. CO.
WESTINGHOUSE LAMP CO.
YALE AND TOWNE MFG. CO.

(Continued from page 370)

Effective January 1, 1934, William J. Filbert succeeds to the office of Chairman of the Finance Committee of the United States Steel Corporation, a position now held by Myron C. Taylor who, following the change, will continue as Chairman of the Board of Directors and Chief Executive Officer of the Steel Corporation. Mr. Filbert has been Vice Chairman of the Finance Committee since January 26, 1932.

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John Urquhart is the new General Superintendent of the Woodward Iron Co., Woodward, Ala., in charge of blast furnaces and coke works. For a number of years he was with the Semet Solvay Co., at Detroit and New York.

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Dennis E. Benbow, until recently Superintendent of the Sheet and Jobbing Division, Bethlehem Steel Co., Sparrows Point, Md., has become Superintendent of Sheet Mills with the Australian Iron & Steel Ltd., and will sail from San Francisco December 20 for Sydney, Australia, to assume his new duties immediately.

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John H. Nelson, Negaunee, Mich., General Superintendent of the Marquette range ore properties of Republic Steel Corp., Youngstown, Ohio, has been appointed General Manager of the company's Lake Superior district ore properties, succeeding F. J. Webb who died December 4.

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D. E. Wilson, Vice President and Treasurer, Woodward Iron Co., Woodward, Ala., has resigned, effective December 31. He has been with the company for over 22 years.

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Edward R. Stettinius, Jr., at present Vice President of General Motors Corp., has been appointed Vice Chaiman of the Finance Committee of the United States Steel Corp., effective April 1, 1934.

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On January 1, F. W. Waterman retires as President of the National Tube Co., subsidiary of the Steel Corporation, under its pension plan, ending a practically unbroken tenure with the corporation and its predecessors since 1892. On January 1, 1929, he succeeded Taylor Allderdice as president of the Tube company. Mr. Allderdice in turn was successor to William B. Schiller.

The new president of National Tube Company is Benjamin F. Harris, now President of the Oil Well Supply Co., also a Steel corporation subsidiary, which post he will retain for the present. Mr. Harris entered the service of the American Sheet & Tin Plate Co. in 1903, becoming Vice President and General Manager of the Wilson-Snyder Co., from which he was transferred in 1929 to the presidency of the Oil Well Supply Co.

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Roy M. Welch has been named assistant to Frank Purnell, President, Youngstown Sheet & Tube Co., Youngstown, Ohio. Formerly he was Assistant Treasurer and Assistant Secretary. R. C. Steese, Youngstown, has been elected a member of the executive committee of the board of directors.

John Follansbee, President of the Follansbee Bros. Company, has announced the appointment of G. A. White as Vice President in Charge of Production, this covering operations at both the Follansbee, W. Va. and Toronto, Ohio, Plants, the management of which plants remains as heretofore, with Mr. Lake at Follansbee and Mr. Marlier at Toronto.

Mr. White has had a broad experience in Open Hearth practice, Sheet, Strip and Tin Plate production. He was a pioneer in the normalizing of Sheet Steel for deep drawing requirements and has assisted the Industry to a considerable extent in the rapid improvement which has been accomplished in the quality of Electrical Sheet Steel.

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Wayne H. Perry, attached to the office of J. W. Lewis, assistant to President Gerard Swope of the General Electric Company, has been elected an assistant secretary of the company. He will have offices in the new G. E. building, 570 Lexington avenue.

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B. C. Hooper, formerly Sales Manager of the Industrial Truck Division of the Baker-Raulang Company, Cleveland, Ohio, has recently been placed in charge of this company's Chicago Sales Offices.

For many years Mr. Hooper acted in the capacity of dealer of the Baker-Raulang Company in St. Paul; was then transferred to the Cleveland factory as special railroad representative, and in 1929 was made Sales Manager.

W. F. Hebard, formerly of the W. F. Hebard Company who represented the Baker-Raulang Company for many years in Chicago, is associated with Mr. Hooper and will continue to handle their railroad activities.

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J. M. Lutz has been appointed Western Representative for the United Engineering and Foundry Company and is located in Chicago with offices in the 208 South LaSalle Building. Mr. Lutz has been connected in the past with American Steel and Wire Company, the Tennessee Coal, Iron and R. R. Company, and for the past ten years with the Pennsylvania Lubricating Company as General Manager of Sales.

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As part of an extensive national sales expansion program, The Louis Allis Co., of Milwaukee, Wis. announces the appointment of four new members to their sales organization as follows:

C. F. Cate, 212 North 3rd Street, Albuquerque, New Mexico, has been appointed representative for the state of New Mexico.

Robert B. Soderberg will represent the company in the state of Connecticut with headquarters at 196 Palm Street, Hartford, Connecticut.

N. O. Lawyer has joined the sales organization working out of the company's New York office located at Room 385, 50 Church Street.

G. W. Conner has joined forces with the Cincinnati office located at 1124 Chamber of Commerce Building.

The Combustion Engineering Company, Inc., announces the following new appointments:

James Cleary, who has been a sales executive of the company for many years, has been appointed manager of the Philadelphia sales district and will make his headquarters at the company's Philadelphia office, 1616 Walnut Street.

Fred L. Farrell has been appointed manager of the New England sales territory and will make his headquarters at the company's Boston office, Chamber of Commerce Building. Mr. Farrell has had a long identification with sales work in this field, and was previously associated with this company in the same office he now holds.

G. O. French has been engaged as a sales engineer specializing on sales work in connection with the company's fire-tube boilers and all special shop work such as oil refinery equipment, chemical equipment, special alloy vessels, tanks, plate work, etc. Mr. French was previously New York District Sales Manager of The Air Preheater Corporation, and prior to that was a sales engineer of the Walsh & Weidner Boiler Company.

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O. B. Schmeltz, formerly of the Putnam Machine Works of Manning, Maxwell & Moore and more recently connected with The Arch Machinery Company of Pittsburgh, has become associated with Thomas M. Rees, 18 Fancourt St., Pittsburgh, Pa., in representing Bryant Machinery & Engineering Company in the Pittsburgh District.

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WITH THE MANUFACTURERS

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A new booklet, "CR 7505 Photoelectric Relays" is now ready for distribution by the General Electric Company of Schenectady, N. Y. This well illustrated booklet contains 16 pages and may be obtained by writing the above company and requesting Booklet GEA-1654A. This supersedes GEA-1654.

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The Allis Chalmers Manufacturing Company of Milwaukee, Wis., have prepared a four-page bulletin on Feeder Voltage Regulators, Type AFR. Copy of this Bulletin may be secured by writing for Bulletin 3023.

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New Metal Home Building Company

The latest entrant in the metal home building field is the Universal House Corporation, of Zanesville, Ohio. This company has announced its intention of producing houses at prices within the reach of the man of small income.

Universal Houses has been working quietly for over a year, but has been reluctant to invite publicity believing that the intense public interest in metal homes would delay development work. For that reason its experimental house was built in rather a remote location.

The recent opening of this house marked the first opportunity of the general public to see what had been accomplished. Dedication ceremonies were held on December 12, on which occasion Bernard L. Johnson, Editor of the "American Builder" and Hugh W. Wright, of The American Rolling Mill Company, were the speakers.

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"Arc Arrester" Aids Industrial Contactors

Without introducing mechanical devices to suppress the arc it is possible to speed a. c. arc extinctions with a simple, rugged, single-break type of contactor by inclusion of an "arc arrester". This recent development by Westinghouse for mounting on the base of a contactor or linestarter involves a small unit consisting of a small capacitor and resistor connected across the poles on the load side of the contacting device.

Effectiveness of the development is said to be startling. Oscillograms show less than one-half cycle arcing with the arc arrester as against a persistence of five to eight half cycles under otherwise identical conditions without it. This example involved tests at 550 volts, 60 cycles with a 7½ HP. motor, rotor locked, as load.

In practical installations but one unit is required for a three-phase contactor and relief is afforded not only for the contactor, or linestarter upon which it is mounted, but also for any disconnect, operating switch, fuse or other rupturing device connected ahead of the contactor. On three-phase reversing service but one "arc arrester" is required as it acts with equal effectiveness to relieve either the forward or reversing contactor.

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Totally Enclosed, Fan-cooled Synchronous Motor

Electric Machinery Mfg. Company, Minneapolis, Minn. announces the development of a totally-enclosed, fan-cooled synchronous motor. This motor is designed for use in locations where corrosive atmospheres prevail, or where motors are subject to salt-water or other sprays. Working parts of the motor are totally enclosed, and sealed from exterior atmosphere; the motor exterior is treated to prevent corrosion. Motor cooling is secured by internal recirculation of air. These synchronous motors are available in practically any horsepower or speed rating to meet any kind of corrosive atmospheric condition.

Five of these motors, rated 300 HP, 360 RPM, and 720 RPM, were recently sold to a chemical company operating on the Atlantic seaboard.

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Flanged Precision Spindle Bearings

From the New Departure Manufacturing Company comes announcement of a line of precision ball bearings flanged for use on spindles.

The following advantages are claimed for this new product:

1. The shoulders are on the bearing instead of in the housings.
2. Thus, it is possible to bore housings straight through at one set-up, thereby assuring perfect alignment.
3. The bearings are separable for quick and easy assembly.
4. Inner rings are extra wide to assure firm non-deflecting seating and are key-slotted so that they may be locked to prevent creeping

about the shaft. Preload is applied through the inner rings.

These bearings are supplied in sizes from 30 mm. up to 130 mm. bore, to precision specifications, and are obtainable in two bore sizes for each standard outside diameter.

Literature describing this latest development in ball bearings may be obtained by addressing the New Departure Manufacturing Company, at Bristol, Conn.

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New Indicating Lamps Announced by General Electric

A new indicating lamp which can be used for signal-light indication or, in combination with control switches, to tell whether a circuit breaker is open, closed, or tripped automatically has been announced by the General Electric Company. This indicating lamp offers the advantages of long lamp-life and low-wattage consumption and is intended for application where good visible indication is desired.

The indicating lamp unit consists of a resistor of the vitreous-enamel type, a receptacle and escutcheon constructed of insulating material, permitting their use on metal panels, a 24-volt lamp, and a color cap which may be clear, red, yellow, or green. The escutcheon, which is mounted in the panel hole from the front, and the receptacle body, which is mounted from the rear, are threaded to make a compact unit when assembled. The resistor element slides over the receptacle body from the rear, and the complete device provides for soldered connections. Binding screws are included for use when soldered connections are not desired. The color caps are made of a special translucent compound which has been treated to give more glow and greater visibility when the lamp is lighted.

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Winners of Contest for Naming New Gas Analyzer for Furnace Atmospheres

In the contest recently held by the Bacharach Industrial Instrument Company to stimulate suggestions of a name for their new analyzer for furnace atmospheres, the following names were selected by the judges to receive awards.

Name—Furnacescope. Contestant — Victor E. Amspacher, Chemist, Pennsylvania Railroad, Altoona, Pa.

Name—Furnace Master. Contestant—T. F. Dowling, Steam Engineer, Gulf States Steel Co., Gadsden, Alabama.

Name—Furnacescope. Contestant—John Lehnert, Combustion Engineer, Republic Steel Corp., Canton, Ohio.

Name—Gas Corrector. Contestant—R. H. Rowley, Asst. Chief Inspecting Engr., Pittsburgh Steel Co., Allenport, Pa.

Name — Atmostroller. Contestant — A. L. Wilhoite, Steam Engineer, Youngstown Sheet & Tube Co., Youngstown, Ohio.

The analyzer will be recalled as the one shown in the Bacharach Industrial Instrument Company's booth at the recent A. I. & S. E. E. Iron and Steel Exposition in Pittsburgh, October 17-18-19, 1933.

General Electric Announces Improved Pressure Governors

An improved line of pressure governors, designated as type CR2922, has been developed by the General Electric Company. Although these governors are especially adapted for pumping station service, they can be readily used in industrial processes where it is desired to maintain a predetermined pressure. The scale of these new governors can be furnished to read water heads in feet instead of the usual pounds per square inch.

Adjustments can be made on the governors between the limits of 20 to 80 per cent of the full scale rating. The maximum differential is 60 per cent and the minimum is 2 per cent of the full scale rating. Accuracy at a setting is 1 per cent of the full scale.

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American Iron and Steel Institute Notes

Although production in the iron and steel industry declined about 9 per cent in October, compared with September, employment fell off only ¼ of 1 per cent and payrolls increased by nearly $800,000 to a total of $37,977,385.

Employment in the industry in October totalled 416,277 against 417,020 in September and 338,146 in June. In 1932 the total dropped to 210,000.

These facts are shown in the second monthly report on employment, hours and wages in the steel industry, compiled by the American Iron & Steel Institute, under the Steel Code which has been transmitted to the National Recovery Administration in Washington.

Under the operation of the Steel Code, employment in the industry at the present time, with greatly reduced operations, is close to the level of 420,000 estimated by the National Recovery Administration for 1929 when average operations approximated 80 per cent of capacity.

According to the Institute, an expansion of operations in the industry to as much as 70 per cent of capacity would require approximately 125,000 additional employees. Many of these would be skilled operators and present indications are that the present supply of such workers would be exhausted long before requirements could be filled.

Some shortage of skilled labor already has developed within the industry. Under the Steel Code, all employees who are permitted in emergency cases to work more than 48 hours and more than six days in any one week must be reported to the Institute. During October, 18.6 per cent of all such cases were due to over-time resulting from a lack of trained men and over-time necessary to train new men to do the work.

The industry is making rapid progress in adjusting its hours of employment under the conditions of the Steel Code. The report shows that 84 per cent of all employees in the industry were working 40 hours a week or less during the last week of October. In that week only 0.41 per cent of the total number employed were working more than 48 hours and only 0.06 per cent of the total worked more than six days.

Average earnings for iron and steel employees amounted to 57.9 cents per hour in October compared with 56.7 cents in September and 47.3 cents in June. The average increase since June was thus

22.4 per cent. In the same period average hours per week per employee decreased 20.8 per cent.

The figures show further that despite the reduced operations in October compared with September, average earnings per hour increased approximately 2 per cent. This resulted from the change from the 10-hour to the 8-hour day with a consequent increase of rate of pay per hour for all employees affected.

Commenting upon the figures, a statement by the American Iron and Steel Institute said:

"No cases of alleged violation of the Code by any member have come to the attention of the Code authority during the month.

"Results of the survey show unquestionably the willingness of the members of the Steel Code to give 100 per cent co-operation. As a result rapid progress is being made in the industry in its voluntary efforts to comply strictly with the Code and to carry out the principles and policies of the NRA in so far as they are required in the Steel Code."

ASSOCIATION NOTES

COMING MEETINGS AND PAPERS

Philadelphia Section

W. H. Burr, Chairman L. O. Morrow, Secretary
Engineers' Club 7:00 P. M.
January 6, 1934

"Design and Application of Gearmotors," by R. P. Marthens, Manager of Engineering, Westinghouse Electric & Manufacturing Company, Nuttall Works, Pittsburgh, Pa. Meeting will be held at Engineers' Club, 1317 Spruce street, Philadelphia, Pa., at 7:00 P. M. Informal Dinner at 6:00 P. M.

Pittsburgh Section

J. W. Bates, Chairman J. I. Kaspari, Secretary
William Penn Hotel 7:30 P. M.
January 19, 1934

"Life in the U. S. S. R.," by Gordon Fox, Electrical Engineer, Freyn Engineering Co., Chicago, Ill.

Gordon Fox, well known A. I. & S. E. E. member, will present movies taken by himself on his travels through the U. S. S. R. Mr. Fox has spent the major portion of the last five years in Russia in connection with steel mill work which Freyn Engineering Company has been doing for the Soviet Union. He was permitted to use his movie camera without restrictions and brings to us an unbiased, true to life picture of conditions in Russia as he saw them. The movies will be accompanied by explanatory remarks by Mr. Fox.

This meeting will be a joint session of the Pittsburgh Section of the Association of Iron and Steel Electrical Engineers, Pittsburgh Section of the American Institute of Electrical Engineers and the Engineers' Society of Western Pennsylvania.

Chicago Section

K. E. Dinius, Chairman A. J. Whitcomb, Secretary
January, 1934

"Commutation," by C. Lynn, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Definite Date will be announced later.

Cleveland Section

L. A. Terry, Chairman W. W. Spanagel, Secretary
January Meeting notice will be printed later.

Birmingham Section

E. P. Winters, Chairman J. B. Looney, Secretary
January Meeting notice will be printed later.

OBITUARIES

Henry Herman Westinghouse, 80, Chairman of the Board of Directors of the Westinghouse Air Brake Company and an outstanding mechanical engineer, died November 18, at his home in Goshen, N. Y.

His engineering career began in the shop of his father, who was a manufacturer of patented agricultural machinery.

As a boy, he attended the Union High School in Schenectady, N. Y. He was graduated in 1870, studied mechanical engineering at Cornell University in 1871, and the following year came to Pittsburgh to become associated with the Westinghouse Air Brake Company. Based largely upon the inventions of Mr. Westinghouse's brother, George, the company had been organized in 1869.

Mr. Westinghouse learned the business from the ground up, working in the foundry, machine shop and drafting room. He became general manager in 1887, and vice president in 1899. Upon the death of his brother, George, in 1914, he became president, and was elected chairman of the board of directors a year later.

In 1881, Mr. Westinghouse organized the Westinghouse Machine Company. With William L. Church, Walter C. Kerr and I. H. Davis, he formed the engineering firm of Westinghouse, Church, Kerr & Company and was its president for years.

Besides marked mechanical talents, Mr. Westinghouse was possessed of remarkable executive ability, as may be noted from his 60 years association with the Westinghouse Air Brake Company.

Mr. Westinghouse was director and chairman of board, Westinghouse Air Brake Company; Canadian Westinghouse Company, Ltd.; director, Union Switch & Signal Company, Westinghouse Electric & Manufacturing Company; director and president, Compagnie des Freins Westinghouse, Paris; director, Westinghouse Brake & Saxby Signal Company, Ltd., London; director, Westinghouse Brake Company of Australasia, Ltd., Sydney; director, Westinghouse Brake Subsidiaries, Ltd., London.

Thomas J. Bray, director and member of the executive committee of the Youngstown Sheet & Tube Co., Youngstown, died suddenly in his office in that city on December 11. Mr. Bray had been continuously identified with the steel industry since his graduation from Lehigh University in 1894.

Tillman D. Lynch, aged 66, formerly consulting metallurgical engineer, at the Westinghouse Electric and Manufacturing Company, died at his home in Edgewood, Pa., after several months illness.

John J. Davis, until about 10 years ago Superintendent of the Interstate Iron & Steel Co., East Chicago, Ind., now a part of Republic Steel Corporation, recently died at his home at Fort Benning near Columbus, Ga. Mr. Davis, who was 80 years old, was born in England and came to this country in 1875, his first employment being in a Pittsburgh steel mill.